

VOLUME II: CHAPTER 1

INTRODUCTION TO STATIONARY POINT SOURCE EMISSION INVENTORY DEVELOPMENT

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DISCLAIMER

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ABBREVIATIONS, ACRONYMS, AND SYMBOLS

ABBREVIATIONS

ACT	Alternative Control Technology Guideline
AFS	AIRS Facility Subsystem
AFSEF	AIRS Facility Subsystem Emission Factors Database
AIRS	Aerometric Information Retrieval System
ALAPCO	Association of Local Air Pollution Control Officials
AMS	AIRS Area and Mobile Subsystem
APA	Air Pathway Analysis
API	American Petroleum Institute
APPCD	Air Pollution Prevention and Control Division
APTI	Air Pollution Training Institute
AQS	AIRS Quality Subsystem
ARDS	Acid Rain Data System
ASTM	American Society for Testing and Materials
BACT	best available control technology
BTU	British thermal unit
CAA	Clean Air Act
CAS	Chemical Abstract Services
CD-ROM	compact disc read-only memory
CEM	Continuous Emissions Monitoring
CFC	Chlorofluorocarbon
CFR	Code of Federal Regulations
CERCLA	Comprehensive Environmental Recovery and Comprehensive Liability Act
CHIEF	Clearinghouse for Inventories and Emission Factors
CMS	Continuous Monitoring System

ABBREVIATIONS, ACRONYMS, AND SYMBOLS (CONTINUED)

CO	carbon monoxide
CTC	Control Technology Center
CTG	Control Techniques Guideline
DARS	Data Attribute Rating System
DECIM	Defense Corporate Information Management
DoD	Department of Defense
DOE	Department of Energy
EA	Environmental assessment
EFIG	Emission Factor and Inventory Group
EIIP	Emission Inventory Improvement Program
EIS	Environmental Impact Statement
EMTIC	Emission Measurement Technical Information Center
EPA	U.S. Environmental Protection Agency
FIP	Federal Implementation Plan
FR	Federal Register
FIRE	Factor Information Retrieval System
HAP	hazardous air pollutant
HCFC	hydrochlorofluorocarbon
ID	identification
JEIOG	Joint Emission Inventory Oversight Group
LAER	lowest achievable emission rate
LAEEM	Landfill Air Emissions Estimation Model
lb	pound
LDP	locational data policy
MACT	maximum achievable control technology

ABBREVIATIONS, ACRONYMS, AND SYMBOLS (CONTINUED)

MSDS	material safety data sheets
MWC	municipal waste combustors
NAAQS	National Ambient Air Quality Standard
NEC	not elsewhere classified
NEDS	National Emissions Database System
NEPA	National Environmental Policy Act
NATICH	National Air Toxics Information Clearinghouse
NADB	National Allowance Database
NO _x	nitrogen oxides
NPL	national priority list
NSPS	New Source Performance Standard
NSR	new source review
NTIS	National Technical Information Service
OAQPS	Office of Air Quality Planning and Standards
OMB	Office of Management and Budget
ORD	Office of Research and Development
PC	personal computer
PC-BEIS	Personal Computer-Biogenic Emissions Inventory System
PL	Public Law
PM	particulate matter
PM ₁₀	particulate matter of aerodynamic diameter less than or equal to 10 micrometers
PM _{2.5}	particulate matter of aerodynamic diameter less than or equal to 2.5 micrometers
POTW	publicly owned treatment works
PPM	parts per million
PSD	prevention of significant deterioration

ABBREVIATIONS, ACRONYMS, AND SYMBOLS (CONTINUED)

QA	quality assurance
QC	quality control
RACT	reasonably available control technology
RCRA	Resource Conservation and Recovery Act
RE	rule effectiveness
RFP	reasonable further progress
RVP	Reid vapor pressure
SARA	Superfund Amendments and Reauthorization Act
SAEWG	Standing Air Emissions Work Group
STAPPA	State and Territorial Air Pollution Program Administrators
SCC	Source Classification Code
SIC	Standard Industrial Classification
SIP	state implementation plan
SO ₂	sulfur dioxide
TAP	toxic air pollutant
tpy	tons per year
TRAC	Tracking Responses to Acid Rain Compliance
TRIS	Toxic Chemical Release Inventory System
TSDf	treatment, storage, and disposal facility
U.S.	United States
U.S.C.	United States Code
UTM	universal transverse mercator
VOC	volatile organic compound

DEFINITIONS OF COMMONLY USED TERMS

Actual Emissions are the actual rate of emissions of a pollutant from an emissions unit calculated using the unit's actual operating hours, production rates, and types of materials processed, stored, or combusted during the selected time period.

Allowable Emissions are the emissions rate that represents a limit on the emissions that can occur from an emissions unit. This limit may be based on a federal, state, or local regulatory emission limit determined from state or local regulations and/or 40 Code of Federal Regulations (CFR) Parts 60, 61, and 63.

Ambient Standards limit the concentration of a given pollutant in the ambient air. Ambient standards are not emissions limitations on sources, but usually result in such limits being placed on source operation as part of a control strategy to achieve or maintain an ambient standard.

Area Sources are smaller sources that do not qualify as point sources under the relevant emissions cutoffs. Area sources encompass more widespread sources that may be abundant, but that, individually, release small amounts of a given pollutant. These are sources for which emissions are estimated as a group rather than individually. Examples typically include dry cleaners, residential wood heating, auto body painting, and consumer solvent use. Area sources generally are not required to submit individual emissions estimates.

Carbon Monoxide (CO) is a colorless, odorless gas that depletes the oxygen-carrying capacity of blood. Major sources of CO emissions include industrial boilers, incinerators, and motor vehicles.

Class I Substances as defined in Title VI of the Clean Air Act Amendments include chlorofluorocarbons (CFCs), halons, carbon tetrachloride, and methyl chloroform. According to the CAAA, all of these compounds must be phased out of production by the year 2000 with the exception of methyl chloroform, which must be phased out of production by the year 2002. Provisions are also made that allow for acceleration of this phaseout.

Class II Substances as defined in Title VI of the Clean Air Act Amendments include hydrochlorofluorocarbons (HCFCs). These substances must be phased out of production by the year 2015.

Continuous Emissions Monitoring (CEM) is any monitoring effort that "continuously" measures (i.e., measures with very short averaging times) and records emissions. In addition to measuring and recording actual emissions during the time of monitor operation, CEM data can be used to estimate emissions for different operating periods and longer averaging times.

Criteria Pollutants are carbon monoxide (CO), lead (Pb), nitrogen oxides (NO_x), sulfur dioxide (SO₂), volatile organic compounds (VOCs), and particulate matter of aerodynamic diameter less than or equal to 10 micrometers (PM₁₀). The National Ambient Air Quality Standards (NAAQS) were mandated by the Clean Air Act of 1970, and are based on criteria including adverse health or welfare effects. NAAQS are currently used to establish air pollutant concentration limits for the six air pollutants listed above that are commonly referred to as **criteria pollutants**.

Design Standards impose certain hardware requirements. For example, a design standard might require that leaks from compressors be collected and diverted to a control device. Design standards are typically used when an emissions limit is not feasible.

Emission Concentration Standards limit the mass emissions of a pollutant per volume of air. Emission concentration standards are expressed in terms such as grams per dry standard cubic meter (g/dscm) or other similar units.

Emission Factors are ratios that relate emissions of a pollutant to an activity level at a plant that can be easily measured, such as an amount of material processed, or an amount of fuel used. Given an emission factor and a known activity level, a simple multiplication yields an estimate of the emissions. Emission factors are developed from separate facilities within an industry category, so they represent typical values for an industry, but do not necessarily represent a specific source. Published emission factors are available in numerous sources.

Emissions Reduction Standards limit the amount of current emissions relative to the amount of emissions before application of a pollution control measure. For example, an emission reduction standard may require a source to reduce, within a specified time, its emissions to 50 percent of the present value.

Emission Standards are a general type of standard that limit the mass of a pollutant that may be emitted by a source. The most straightforward emissions standard is a simple limitation on mass of pollutant per unit time (e.g., pounds of pollutant per hour).

Engineering Estimate is a term commonly applied to the best approximation that can be made when the specific emission estimation techniques such as stack testing, material balance, or emission factor age are not possible. This estimation is usually made by an engineer familiar with the specific process, and is based on whatever knowledge may be available.

Equipment Standards require a specific type of equipment to be used in certain processes. Equipment standards are typically used when an emissions limit is not feasible.

Fugitive Emissions are emissions from sources that are technically infeasible to collect and control (e.g., storage piles, wastewater retention ponds).

Hazardous Air Pollutants (HAPs) are listed in Section 112(b) of the 1990 Clean Air Act Amendments (CAAA). These pollutants are generally emitted in smaller quantities than criteria pollutants but may be reasonably anticipated to cause cancer, developmental effects, reproductive dysfunctions, neurological disorders, inheritable gene mutations, or other chronically or acutely toxic effects in humans. The CAAA specifies an initial list of 189 HAPs to be subject to further regulation. The list of HAPs includes relatively common pollutants such as formaldehyde, chlorine, methanol, and asbestos, as well as numerous less-common substances. Pollutants may, under certain circumstances, be added to or deleted from the list.

Lead (Pb) is an element that causes several types of developmental effects in children including anemia, neurobehavioral alterations, and metabolic alterations. Lead is emitted from industries such as battery manufacturing, lead smelters, and incineration. Although regulated in highway fuels, lead may also be emitted from unregulated off-highway mobile sources.

Material Balance or **Mass Balance** is a method for estimating emissions that attempts to account for all the inputs and outputs of a given pollutant. If inputs of a material to a given process are known and all outputs except for air emissions can be reasonably well quantified, then the remainder can be assumed to be an estimate of the amount lost to the atmosphere for the process.

Maximum Achievable Control Technology (MACT) Standards in addition to National Emissions Standards for Hazardous Air Pollutants (NESHAP), are promulgated under Section 112 of the Clean Air Act Amendments (CAAA). Technically NESHAP and MACT standards are separate programs. MACT standards differ from older NESHAPs because MACT standards are mandated by law to require the maximum achievable control technology. MACT standards are source category-specific, and each standard covers all the pollutants listed in Section 112 of the CAAA that are emitted by that source category. The first MACT standard promulgated (for the Synthetic Organic Chemical Manufacturing Industries) was originally developed as a NESHAP and is still referred to as the Hazardous Organic NESHAP (HON).

Means of Release to the Atmosphere is the mechanism by which emissions enter the atmosphere. Environmental agencies usually classify release mechanisms into three categories: process

emissions, fugitive emissions, and process fugitive emissions. This characteristic of an emission source is important because emission factors and other estimation methods are specific to the type of release.

Mobile Sources include all nonstationary sources, such as automobiles, trucks, aircraft, trains, construction and farm equipment, and others. Mobile sources are a subcategory of area sources, and are generally not required to submit individual emissions estimates.

National Ambient Air Quality Standards (NAAQS) are the main ambient standards for the following six criteria pollutants: carbon monoxide (CO), lead (Pb), nitrogen oxides (NO_x), sulfur oxides (SO_x), ozone (O₃), and particulate matter of aerodynamic diameter less than or equal to 10 micrometers (PM₁₀).

National Emissions Standards for Hazardous Air Pollutants (NESHAP) are a class of standards limiting emissions of HAPs. The common usage of NESHAP actually refers to two different sets of standards. First, there are 22 emissions standards promulgated prior to the 1990 Clean Air Act Amendments (CAAA). Some of these standards are pollutant-specific (e.g., the NESHAP for vinyl chloride), others are source-category specific (e.g., the NESHAP for benzene waste operations), and still others are both pollutant- and source-category specific (e.g., the NESHAP for inorganic arsenic emissions from glass manufacturing plants).

New Source Performance Standards (NSPS) are promulgated for criteria, hazardous, and other pollutant emissions from new, modified, or reconstructed sources that the U.S. Environmental Protection Agency (EPA) determines contribute significantly to air pollution. These are typically emission standards, but may be expressed in other forms such as concentration and opacity. The NSPS are published in 40 Code of Federal Regulations (CFR) Part 60.

Nitrogen Oxides (NO_x) are a class of compounds that are respiratory irritants and that react with volatile organic compounds (VOCs) to form ozone (O₃). The primary combustion product of nitrogen is nitrogen dioxide (NO₂). However, several other nitrogen compounds are usually emitted at the same time (nitric oxide [NO], nitrous oxide [N₂O], etc.), and these may or may not be distinguishable in available test data. They are usually in a rapid state of flux, with NO₂ being, in the short term, the ultimate product emitted or formed shortly downstream of the stack. The convention followed in emission factor documents is to report the distinctions wherever possible, but to report total NO_x on the basis of the molecular weight of NO₂. NO_x compounds are also precursors to acid rain. Motor vehicles, power plants, and other stationary combustion facilities emit large quantities of NO_x.

Opacity Standards limit the opacity (in units of percent opacity) of the pollutant discharge rather than the mass of pollutant.

Operational Standards impose some requirements on the routine operation of the unit. Such standards include maintenance requirements or operator training certification requirements. Operational standards are typically used when an emission limit is not feasible.

Ozone (O_3) is a colorless gas that damages lungs and can damage materials and vegetation. It is the primary constituent of smog, and is formed primarily when nitrogen oxides (NO_x) and volatile organic compounds (VOCs) react in the presence of sunlight. It is also emitted in insignificant quantities from motor vehicles, industrial boilers, and other minor sources.

Particulate Matter of aerodynamic diameter less than or equal to 10 micrometers (PM_{10}) is a measure of small solid matter suspended in the atmosphere. Small particles can penetrate deeply into the lung where they can cause respiratory problems. Emissions of PM_{10} are significant from fugitive dust, power plants, commercial boilers, metallurgical industries, mineral industries, forest and residential fires, and motor vehicles.

Particulate Matter of aerodynamic diameter less than or equal to 2.5 micrometers ($PM_{2.5}$) is a measure of fine particles of particulate matter that come from fuel combustion, agricultural burning, woodstoves, etc. On November 27, 1996 the U.S. Environmental Protection Agency proposed to revise the current primary (health-based) PM standards by adding a new annual $PM_{2.5}$ standard.

Plant Level Emissions are consolidated for an entire plant or facility. A plant may contain one or many pollutant-emitting sources.

Plant Level Reporting is generally required if total emissions from a plant (which may be composed of numerous individual emission points) meet the point source cutoff. These data can be used by the state to conduct a detailed estimate of emissions from that plant. The plant level reporting used by most air pollution control agencies generally requires that the facility provide data that apply to the facility as a whole. Such data include number of employees and the Standard Industrial Classification (SIC) code designation for the plant. A plant usually has only one SIC code denoting the principal economic activity of the facility. For the purpose of clearly identifying and tracking emissions data, each plant is generally assigned a plant (alternatively, "facility") name and number. The plant is also identified by geographic or jurisdictional descriptors such as air quality control region, county, address, and universal transverse mercator (UTM) grid coordinates (or latitude/longitude) that identify a coterminous location. An owner or operator engaged in one or more related activities is also identified. In some cases, plantwide emissions may be reported at the plant level.

Point Level Emissions typically represent single stacks or vents individually large enough to be considered point sources.

Point Level Reporting includes specific data for individual emission points (typically stacks). These data are more detailed than that submitted in Plant Level Reporting and may include emission-related and modeling information such as stack height of the release point, diameter of the stack, emission rate, method of determination, fugitive emissions, gas exit velocity from a stack, gas temperature, and operating schedule. Source identification information, as previously described under Plant Level Reporting, is usually also required at the point level to ensure that emission data for a single plant remain clearly identified. Regulatory agencies generally maintain individual emission-related records at the point level.

Point Sources are large, stationary, identifiable sources of emissions that release pollutants into the atmosphere. Sources are often defined by state or local air regulatory agencies as point sources when they annually emit more than a specified amount of a given pollutant, and how state and local agencies define point sources can vary. Point sources are typically large manufacturing or production plants. They typically include both confined "stack" emission points as well as individual unconfined "fugitive" emission sources.

Within a given point source, there may be several **emission points** that make up the point source. Emissions point refers to a specific stack, vent, or other discrete point of pollution release. This term should not be confused with point source, which is a regulatory distinction from area and mobile sources. The characterization of point sources into multiple emissions points is useful for allowing more detailed reporting of emissions information.

For point sources, the emission estimate reporting system used by most state and local air regulatory agencies groups emission sources into one of three categories and maintains emission-related data in a different format for each. The three categories are plant level, point level, and process or segment level.

Potential Emissions are the potential rate of emissions of a pollutant from an emissions unit calculated using the unit's maximum design capacity. Potential emissions are a function of the unit's physical size and operational capabilities.

It is important to note that annual potential emissions from a unit are not necessarily the product of 8760 hours per year times the hourly potential emissions. For most processes, the operation of one piece of equipment is limited in some way by the operation of another piece of equipment upstream or downstream. For example, consider a batch process involving vessels X, Y, and Z in series (i.e., the output from Vessel X is the feed to Vessel Y, and the output from Vessel Y is the feed to Vessel Z) where the residence time for each vessel is different. In this process, Vessel Y may not operate 8760 hours per year because either the output from Vessel X is not feeding Vessel Y at all times or Vessel Z may not always be available to accept the output from Vessel Y.

It is also possible for the emission rate to vary over time. For instance, if a reaction requires 6 hours to reach completion, the emissions from the reaction vessel during the first hour will be

different than those during the last hour. Thus, the highest hourly emission rate is not sustained during the entire cycle or for the entire year.

Process-based Emission Standards limit the mass emissions per unit of production. These standards may limit mass emissions per unit of material processed or mass emissions per unit of energy used. As process rate increases (e.g., an increase in tons of ore processed per hour), the allowable emissions increase (e.g., an increase in pounds of pollutant per hour).

Process Emissions are emissions from sources where an enclosure, collection system, ducting system, and/or stack (with or without an emission control device) is in place for a process. Process emissions represent emissions from process equipment (other than leaks) where the emissions can be captured and directed through a controlled or uncontrolled stack for release into the atmosphere.

Process Fugitive Emissions occur as leaks from process equipment including compressors, pump seals, valves, flanges, product sampling systems, pressure relief devices, and open-ended lines. Emissions from the process that are not caught by the capture system are also classified as process fugitive emissions.

Process or Segment Level Emissions usually represent a single process or unit of operation.

Process or Segment Level Reporting involves each process within a plant being identified by a U.S. Environmental Protection Agency (EPA) source classification code (SCC). For point sources, reporting guidelines may require that a plant identify, for each process or operation (designated by SCC), the periods of process operation (daily, weekly, monthly, annually); operating rate data including actual, maximum, and design operating rate or capacity; fuel use and fuel property data (ash, sulfur, trace elements, heat content, etc.); identification of all pollution control equipment and their associated control efficiencies (measured or design); and emissions rates. Source identification information, as previously described under Plant Level Reporting, is usually also required at the process level to ensure that emissions data for a single plant are clearly identified.

Process-specific Empirical Relationships are similar to emission factors in that they relate emissions to easily identifiable process parameters. However, these relationships are represented by more detailed equations that relate emissions to several variables at once, rather than a simple ratio. An example is the estimate for volatile organic compound (VOC) emissions from storage tanks that is based on tank size and throughput, air temperature, vapor pressure, and other variables.

Reported Emissions are those emission estimates that are submitted to a regulatory agency. Emissions inventories can be used for a variety of purposes such as State Implementation Plan (SIP) base year inventories, environmental compliance audits, air quality rule applicability, and

reporting information in an air quality permit application. Emissions can be reported on an actual, potential, or maximum basis. Many state and local air pollution control agencies have rules and regulations that define an allowable emission value for a particular piece of equipment. Because of this, a facility should first define the purpose of the inventory and then choose the appropriate means of reporting emissions to the regulatory agency. For example, SIP base year inventories for point sources would contain actual emissions. However, regulatory applicability and air quality permit applications can require that actual, allowable, and potential emissions be reported.

Source Tests are short-term tests used to collect emissions data that can then be extrapolated to estimate long-term emissions from the same or similar sources. Uncertainties arise when source test results are used to estimate emissions under process conditions that differ from those under which the test was performed.

Stratospheric Ozone-depleting Compounds are chlorofluorocarbons (CFCs), halons, carbon tetrachloride, methyl chloroform, and hydrochlorofluorocarbons (HCFCs). These pollutants are regulated by Title VI of the Clean Air Act Amendments (CAAA) because they may destroy stratospheric ozone. Title VI is primarily designed to limit the manufacture of these materials, not their use. The pollutants are divided into two classes (Class I and Class II) based on the dates by which their manufacture must be discontinued. Methods to estimate emissions of ozone-depleting compounds are not discussed in Emission Inventory Improvement Program (EIIP) documents. Information on emissions of ozone-depleting compounds can be obtained from the U.S. Environmental Protection Agency (EPA) Office of Atmospheric and Indoor Air Programs, Global Climate Change Division, located at EPA Headquarters in Washington, D.C.

Sulfur Oxides (SO_x) are a class of colorless, pungent gases that are respiratory irritants and precursors to acid rain. Sulfur oxides are emitted from various combustion or incineration sources, particularly from coal combustion.

Volatile Organic Compounds (VOCs) react with nitrogen oxides (NO_x) in the atmosphere to form ozone (O_3). Although not criteria pollutants, VOC emissions are regulated under criteria pollutant programs because they are ozone precursors. Large amounts of VOCs are emitted from motor vehicle fuel distribution, chemical manufacturing, and a wide variety of industrial, commercial, and consumer solvent uses.

The use of certain photochemical models requires estimation of methane, ethane, and several other less photochemically reactive compounds and particulates. While not regulated as VOCs, these compounds may need to be estimated for certain modeling inventories or to meet certain state inventory requirements. For this reason, the term **total organic compounds** (TOCs) is used to refer to this broader class of chemicals.

Work Practice Standards require some action during the routine operation of the unit. For example, volatile organic compound (VOC) monitoring of a compressor might be required on a

quarterly basis to ensure no leaks are occurring. Work practice standards are typically used when an emission limit is not practical.

INTRODUCTION

1.1 BACKGROUND

The Clean Air Act, as amended in 1990 (hereafter referred to as the CAA), has expanded the continuing role of the U.S. Environmental Protection Agency (EPA) in its effort to improve air quality in the United States. Among the mandates set forth in the CAA is the requirement that the EPA improve the quality of emission estimates of air pollutants.

Over the last two decades, the CAA and numerous other federal, state, and local programs have required industry to report the amount of air pollutants emitted. With the CAA in place, it is useful for industry to understand the methods used to estimate emissions in order to comply with regulations.

The Emission Inventory Improvement Program (EIIP) is a joint program of the EPA, Standing Air Emissions Work Group (SAEWG), and the State and Territorial Air Pollution Program Administrators and the Association of Local Air Pollution Control Officials (STAPPA/ALAPCO). The ultimate goal of the EIIP is to provide cost-effective, reliable inventories by improving the quality of emissions data collected and provide for uniform reporting of this information. These emissions-related data will be made available to state and local agencies, the regulated community, the public, and EPA. The EIIP has been designed to increase the likelihood that acceptable quality emission inventory data will be available. The use of these procedures will promote consistency in these activities among the emission inventory reporting groups.

Using standardized approaches enables federal, state, and local agencies to generate data of known quality at acceptable or reasonable costs. The EIIP has implemented this concept by selecting preferred and alternative methods for use in determining emissions for various source categories of interest. Their findings are reported in the following series of guidance documents:

- Volume I: *Introduction and Use of EIIP Guidance for Emissions Inventory Development*
- Volume II: *Point Sources Preferred and Alternative Methods*
- Volume III: *Area Sources Preferred and Alternative Methods*
- Volume IV: *Mobile Sources Preferred and Alternative Methods*
- Volume V: *Biogenic Sources Preferred and Alternative Methods*
- Volume VI: *Quality Assurance Procedures*
- Volume VII: *Data Management Procedures*

Volume II in the series of EIIP guidance documents is intended to familiarize the private and government sectors with the basic concepts and procedures involved in estimating air pollutant emissions from point sources. Volume II should also be used to provide state agencies with instructional guidance on preferred methods for developing emission inventories for point sources.

Point sources are those facilities/plants/activities for which individual source records are maintained in the inventory. Under ideal circumstances, all sources would be considered point sources. However, in practical applications, only sources that emit (or have the potential to emit) more than some specified cutoff level of emissions are considered point sources.

Area sources, in contrast, are those activities for which aggregated source and emissions information is maintained for entire source categories rather than for an individual source. Sources not treated as point sources should be included in an area source inventory. Area sources are addressed in Volume III of the EIIP series of guidance documents.

Volume II consists of various combustion, manufacturing, and production activities that comprise point sources. The major chapters within Volume II at various stages of production are as follows:

- Chapter 1: *Introduction to Stationary Point Source Emission Inventory Development*
- Chapter 2: *Preferred and Alternative Methods for Estimating Air Emissions from Boilers*
- Chapter 3: *Preferred and Alternative Methods for Estimating Air Emissions from Hot-Mix Asphalt Plants*
- Chapter 4: *Preferred and Alternative Methods for Estimating Fugitive Air Emissions from Equipment Leaks*
- Chapter 5: *Preferred and Alternative Methods for Estimating Air Emissions from Wastewater Collection and Treatment*
- Chapter 6: *Preferred and Alternative Methods for Estimating Air Emissions from Semiconductor Manufacturing Facilities*
- Chapter 7: *Preferred and Alternative Methods for Estimating Air Emissions from Surface Coating Operations*
- Chapter 8: *Preferred and Alternative Methods for Estimating Air Emissions from Paint and Ink Manufacturing Facilities*

- Chapter 9: *Preferred and Alternative Methods for Estimating Air Emissions from Metal Production Facilities*
- Chapter 10: *Preferred and Alternative Methods for Estimating Air Emissions from Oil and Gas Field Production and Processes*
- Chapter 11: *Preferred and Alternative Methods for Estimating Air Emissions from Plastic Products Manufacturing*

Each industry- or source-specific document contains a brief process description; identification of emission points; an overview of methods available for estimating emissions; example calculations for each technique presented; a brief discussion on quality assurance and quality control; and the source classification codes (SCCs) needed for entry of the data into a database management system. The SCCs included in each volume apply to the process emission points, in-process fuel use, storage tank emissions, fugitive emissions, and control device fuel (if applicable).

1.2 PURPOSE OF CHAPTER 1

Chapter 1 provides an introduction to air pollutant emission assessment, the basic procedures involved in estimating emissions, and industry-specific techniques for estimating emissions. This introductory chapter of Volume II is intended to introduce the information applicable to all stationary point sources as well as identify basic concepts of emission estimation techniques. Practical, detailed calculations and procedures applicable to a specific category are found within subsequent chapters (documents). These later chapters present several different estimation scenarios and provide example calculations to aid in actual emission estimation. Figure 1.1-1 is included to assist readers tasked with inventory preparation in decision making and to refer them to the applicable chapters within this volume and other volumes in the EIIP series. Cumulatively, the chapters of Volume II provide a comprehensive series of manuals which should successfully serve the user in generating a point source emissions inventory.

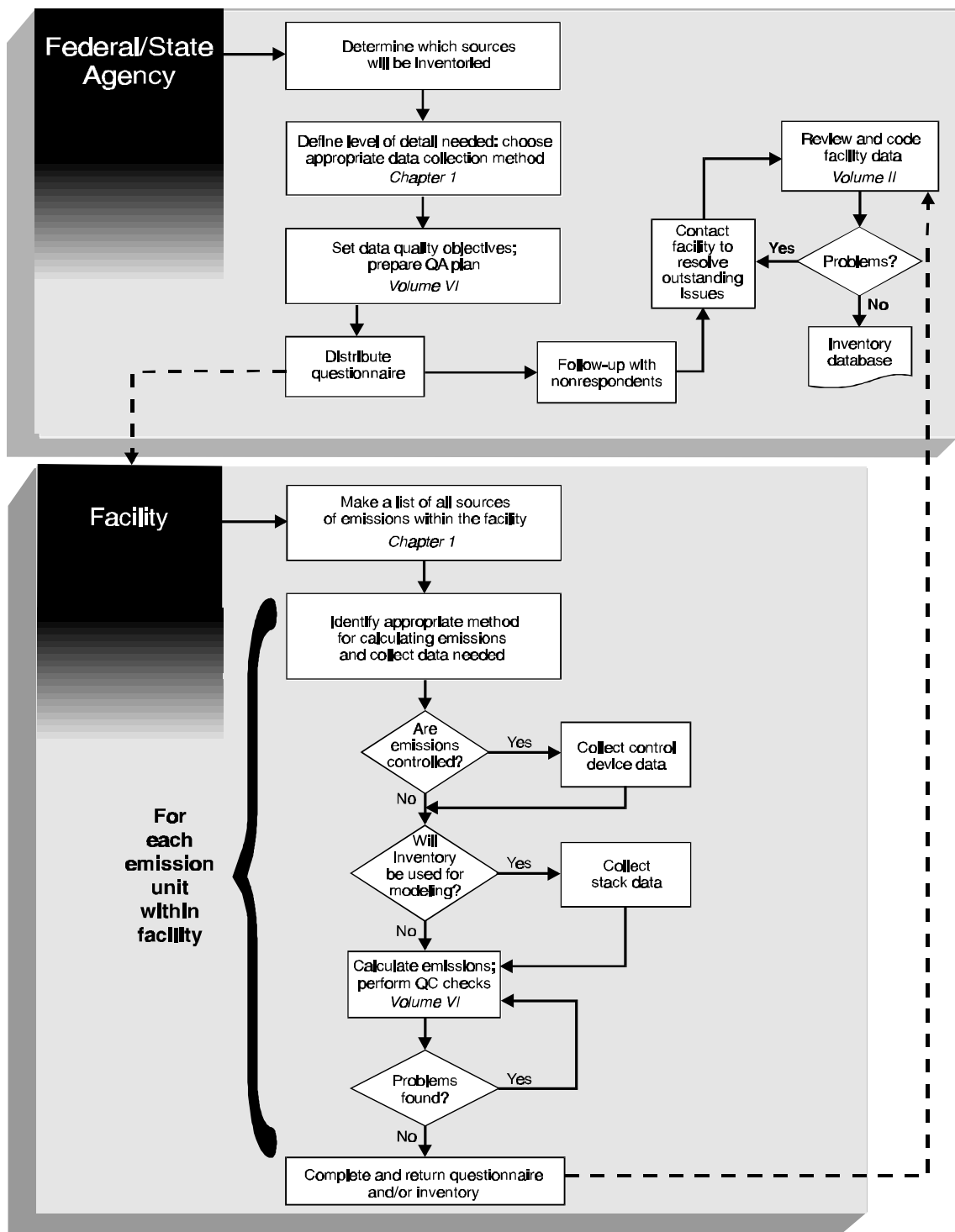


FIGURE 1.1-1. POINT SOURCE INVENTORY DEVELOPMENT PROCESS

1.3 ORGANIZATION OF CHAPTER 1

Section 2 of this chapter identifies several purposes for industry to generate emissions estimates including federal and state regulations, and plant initiatives. Section 3 discusses the emission inventory planning effort, including data handling and documentation requirements. Section 4 describes the basic techniques employed to estimate emissions, including emission factors, source tests, models, and material balances. Section 5 describes the basic procedures followed for data collection and the types of data available for estimating emissions. Section 7 describes quality assurance and quality control procedures and Volume VI of the EIIP series describes quality assurance and quality control procedures in detail. References are provided in Section 8.

Appendix A includes the table of contents from *AP-42, 5th Edition* and Appendix B provides useful conversion factors. Appendix C provides various contact and resource information, and Appendix D presents an example checklist to use to guarantee the completeness of the emissions inventory. Appendix E provides a brief description of the test methods described in individual chapters throughout Volume II. Information on emission estimation tools are presented in Appendix F.

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2

PURPOSES FOR ASSESSING EMISSIONS

In order to comply with various federal and state regulations, sources must initiate an emissions estimation effort. This section primarily focuses on the federal requirements for reporting emissions, while typical state requirements are also briefly discussed. Figure 1.2-1 provides an overview of some of the key emissions estimation relationships among industry, and state and federal agencies (EPA, 1993a).

2.1 FEDERAL REQUIREMENTS

Various federal requirements are linked to emissions estimation requirements. The major federal requirements for both sources and states, with emphasis on those requirements that are likely to lead to emissions estimation requirements for industry, are discussed in this section.

Requirements discussed stem mainly from the Clean Air Act, and from other legislation such as the National Environmental Policy Act (NEPA), the Comprehensive Environmental Recovery and Comprehensive Liability Act (CERCLA), the Superfund Amendments and Reauthorization Act (SARA), the Resource Conservation and Recovery Act (RCRA), and the Pollution Prevention Act. Additional requirements stem from policy issued by the EPA, the Department of Energy (DOE), and the Department of Defense (DoD). The form and content of the specific emissions information varies with each requirement. A useful source for identifying which specific data elements are necessary under each requirement is the document entitled *Integrated Reporting Issues: Preliminary Findings* (EPA, 1992e). Table 1.2-1 provides an overview of the key federal emissions estimation requirements. In addition, Table 1.2-2, taken from the *Integrated Reporting Issues* document, provides an overview of the data elements contained in the major emissions reporting programs described in this section.

2.1.1 CLEAN AIR ACT REQUIREMENTS

The Clean Air Act is the major legislation addressing air pollution in the United States. It mandates a wide variety of programs to manage air quality. The federal air quality management effort begins with the national ambient air quality standards (NAAQS). The NAAQS set nationwide minimum air quality goals. Each state must assess all areas' air

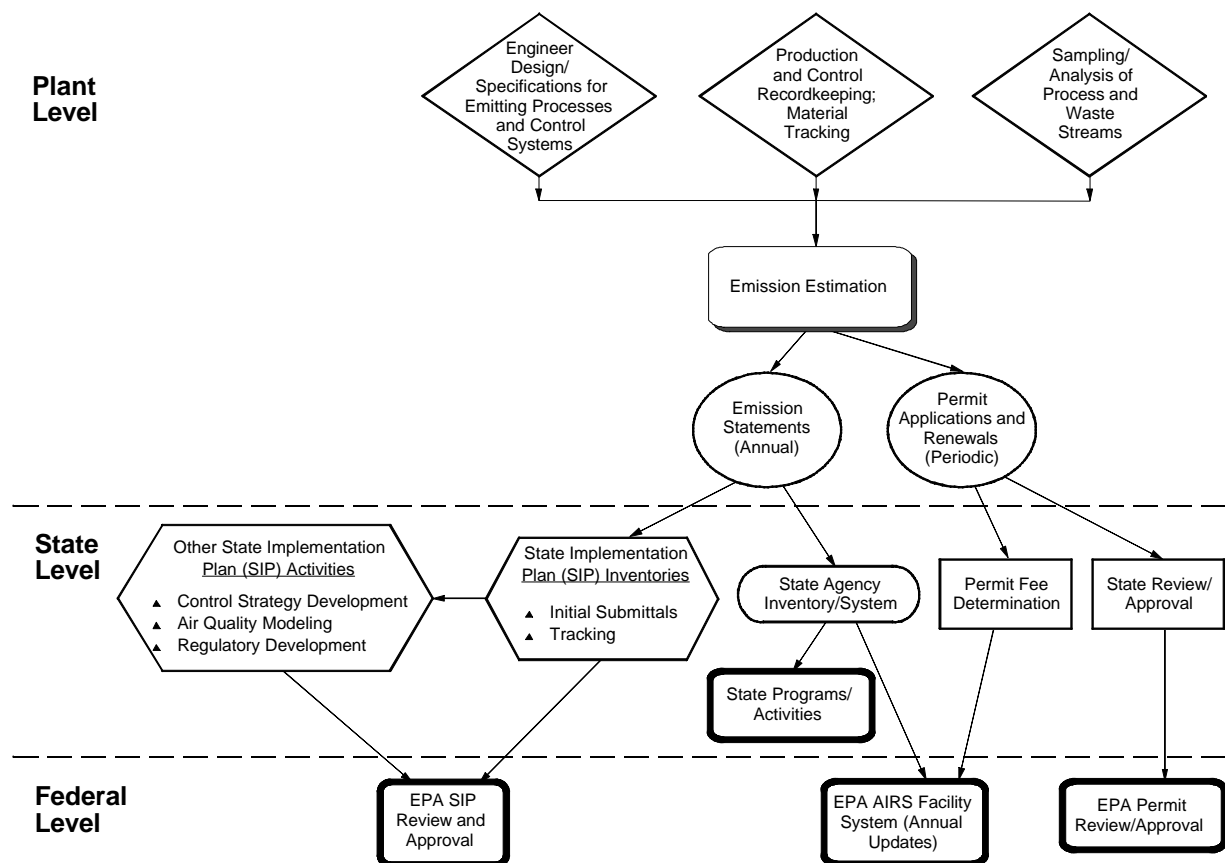


FIGURE 1.2-1. KEY RELATIONSHIPS FOR INDUSTRY AIR POLLUTANT EMISSION ESTIMATION

TABLE 1.2-1

OVERVIEW OF KEY FEDERAL EMISSION ESTIMATION REQUIREMENTS

Statutory Requirement and Agency	Pollutant	Due Date	Size Cutoff	Data Requirements
Annual AIRS Update				
40 CFR 51.321 Agency: State to EPA	PM ₁₀ , sulfur oxides, VOC, NO _x , CO, and lead	July 1, annually	Facility-100 tpy PM ₁₀ , sulfur oxides, VOC, and NO _x ; 100 tpy CO; 5 tpy lead. Point-25 tpy PM ₁₀ , sulfur oxides, VOC, and NO _x ; 250 tpy CO; and 5 tpy lead	General plant information, year of inventory, general operating parameters, emissions data, and control equipment data
Emission Inventory (base year and periodic)				
Clean Air Act Section 172(c)(3) Section 182(a)(1)a Section 182(a)(3)(A) ^a Section 187(a)(1)b Agency: State to EPA	All criteria pollutants	November 15, 1992 and every 3 years thereafter	Point sources-10 tpy VOC; 100 tpy PM ₁₀ moderate; 70 tpy PM ₁₀ serious	General plant information, year of inventory, source operating data, physical data (i.e., stack height, process rate data, source emissions data, and emission limitation data)
Emission Statement				
Clean Air Act Section 182(a)(3)(B)c Agency: Source to state	VOC, NO _x	April 15, annually;	25 tpy VOC or NO _x ; in nonattainment area; 50 tpy VOC or 100 tpy NO _x in attainment portion of transport region	Source identification, source emissions data (annual and typical summer day), control equipment data, process rate data and a certification that the data are accurate

TABLE 1.2-1

(CONTINUED)

Statutory Requirement and Agency	Pollutant	Due Date	Size Cutoff	Data Requirements
Title V Operating Permits				
Clean Air Act Title V Agency: Source to state	All criteria pollutants, all HAPs, CFCs, HCFCs	At time of initial Title V permit application submittal, which is generally one year after EPA approval of state permit program. Annual submission according to state schedule to determine fee basis.	Potential to emit "major" amounts of regulated air pollutants ^{d,e}	General company information, plant description, emissions information, regulatory requirements and compliance information
New Source Review				
Clean Air Act Section 172(c)(5) Agency: Source to state	Criteria pollutants, fluorides, sulfuric acid mist, hydrogen sulfide, total reduced sulfur, reduced sulfur compounds, MWC organics, metals and gases, ozone-depleting substances ^f	Prior to construction or operation of a new or modified major source	Potential to emit "major" amounts for new sources, significant net emissions increase for modified sources	Legal authority, technical specifications, potential emissions, emission compliance demonstration, definition of excess emissions, administrative and other conditions
Economic Incentive Programs (EIP)				
40 CFR Part 51 (some required, some optional) Agency: Source to state	All criteria pollutants	Specific to individual EIP	Major ^d	Specific to individual EIP. Emissions must be "quantifiable."

TABLE 1.2-1

(CONTINUED)

Statutory Requirement and Agency	Pollutant	Due Date	Size Cutoff	Data Requirements
Early Reductions Program				
Clean Air Act Section 112(i)(5) Agency: Source to state	All HAPs as defined in Section 112(b)	Reduction must be achieved before January 1, 1994, therefore demonstration must come before then	Any stationary source	Same as permit with the early reduction demonstration
Urban Air Toxics Program				
Clean Air Act Section 112(k) Agency: EPA to Congress	All HAPs as defined in Section 112(b) or (k)	EPA must report by November 15, 1993	Any source of HAPs contributing to urban concentrations, with emphasis on area sources	Data as necessary to characterize emissions of HAPs and prioritize threats to public health in urban areas
Great Lakes and Coastal Waters Program				
Clean Air Act Section 112(m) Agency: EPA to Congress	All HAPs as defined in Section 112(b)	EPA must report by November 15, 1993, and biennially thereafter	Any source contributing to deposition of HAPs	Data as necessary to determine sources and deposition rates of HAPs
Accidental Release Program				
Clean Air Act Section 112(r)	All extremely hazardous substances as defined in regulation developed under Section 112(r)	As specified in Section 112(r) regulations to be published	Sources emitting amounts above threshold quantities as specified in Section 112(r) regulations to be published	Risk management plan including estimate of potential release quantities, determination of downwind effects, previous release history, and an evaluation of the worst case accidental release

TABLE 1.2-1

(CONTINUED)

Statutory Requirement and Agency	Pollutant	Due Date	Size Cutoff	Data Requirements
New Source Performance Standards				
40 CFR Part 60 Agency: Source to state agency or EPA	SO ₂ , NO _x , total reduced sulfur, hydrogen sulfide, CO, opacity, VOC, PM	30 days after reporting period ends	As specified in standard	Pollutant, reporting period, general company information, emission limitation, monitor manufacturer and model number, data of last CMS certification or audit, process units description, total source operating time, emissions data, CMS performance data
Acid Rain Allowance Trading (Title IV)				
Title IV Clean Air Act	SO ₂ , NO _x	30 days after end of quarter (beginning January 30, 1994 for Phase I and April 30, 1995 for Phase II)	Any facility listed in Table A or B of Title IV or any facility that opts-in (Phase I approx. 110 sources, Phase II approx. 800 sources). Also applies to any new fossil-fuel combustion device that supplies electricity for sale or serves an electricity-generating device that supplies electricity for sale.	General plant information, emissions data, fuel use data
Section 114 General Requirements (i.e., "Section 114 letter")				
Clean Air Act Section 114 Agency: Source to EPA	As specified by EPA	As specified by EPA	Determined case-by-case by EPA	General company information, pollutant, compliance information, operating information

TABLE 1.2-1

(CONTINUED)

Statutory Requirement and Agency	Pollutant	Due Date	Size Cutoff	Data Requirements
Section 114 Compliance Certification				
Clean Air Act Section 114(a)(3) Agency: source to EPA	All criteria pollutants and all hazardous air pollutant as defined in Section 112(a)(1)	30 days after quarter ends, on a quarterly or annual basis	Major ^d	General company information, pollutant, emission information, description of enhanced monitoring system, summary of compliance demonstration, deviation description, violation information, and operation data
National Air Toxics Information Clearinghouse (NATICH)				
Clean Air Act Section 112(1)(3) Agency: State/local agency to EPA	Any hazardous air pollutant (i.e., any noncriteria air pollutant)	Voluntary	Voluntary	Agency name, general plant information, year permit issued, control equipment data, pollutant names, emission limit data, actual emission rate data, source testing data
Best Available Control Technology (BACT)/Lowest Achievable Emission Rate (LAER) Clearinghouse				
N.A. Agency: State/local agency to EPA	Criteria pollutants	Voluntary - after issuance of a BACT or LAER determination	Voluntary	General company information, plant description, year permit issued, emissions data, control technology data, compliance data
National Environmental Policy Act (NEPA)				
PL 91-190 Agency: EPA	Anything that may result in a "significant environmental impact"	Prior to implementation of any federal agency action	NA	Description of the proposed action, alternatives to the action, and environmental, social, and economic impacts of the proposed action and alternatives. May lead to specific requests from EPA to industry

TABLE 1.2-1

(CONTINUED)

Statutory Requirement and Agency	Pollutant	Due Date	Size Cutoff	Data Requirements
Comprehensive Environmental Recovery and Comprehensive Liability Act (CERCLA)				
PL 96-510, amended SARA 42 U.S.C. Section 9601 Agency: Source to state	Chemicals listed in Sections 307, 311 of Clean Water Act, Section 3001 of RCRA, Section 112 of CAA, Section 7 of Toxic Substances Control Act, others designated by EPA under Superfund	Upon release	Releases to the environment that exceed the reportable quantity for that material	Report on release of the toxic substance, including substance and quantity released. (See SARA Section 304.)
Superfund Amendments and Reauthorization Act (SARA)				
SARA Title III Section 313 ("right to know") Agency: EPA and states	EPA designated "toxic chemicals" (329 on original list; 284 added 1995)	July 1, annually	Chemicals used $\geq 10,000$ lb/yr, chemical manufactured or processed $\geq 25,000$ lb/yr	Chemical identify, name, location and principal business identity, certification by senior officials of business, use of each listed chemical, maximum on-site quantity at any time, amount (lb/yr) released to the environment of each chemical, amount (lb/yr) transferred offsite, method of waste treatment and disposal including treatment efficiency, release data (fugitive air emissions in lb/yr, stack/point air emissions in lb/hr, wastewater discharges, releases to land, transfers to off-site locations, underground injection)
SARA Section 304 (hazardous releases) Agency: Source to public	Hazardous substances as defined by CERCLA, extremely hazardous substances as defined by EPA	Immediately upon release	Any episode that releases more than published reportable quantity	Chemical name or identity, quantity released, time and duration of release, media into which released, anticipated health risks, medical attention requirements, precautions, evacuation information, name of person to contact for more information

TABLE 1.2-1

(CONTINUED)

Statutory Requirement and Agency	Pollutant	Due Date	Size Cutoff	Data Requirements
Resource Conservation and Recovery Act (RCRA)				
40 CFR Subtitle C Agency: Source to EPA	Hazardous waste as defined by 40 CFR 261.31, acutely defined by 40 CFR 261.33	Biennially	Small generators: 100-1000 kg non-acutely hazardous waste/month; large generators >1 kg acutely hazardous waste, >1000 kg non-acutely hazardous waste/month	EPA ID number, record of hazardous waste transfers (manifests), records of any test results, waste analyses, etc., waste minimization plan
Pollution Prevention Act				
PL 101-508 Section 6607 Agency: Source to EPA	EPA designated "toxic chemicals"	Annually	Chemicals used \geq 10,000 lb/yr, chemical manufactured or processed \geq 25,000 lb/yr	Toxic chemical source reduction and recycling report

Source: EPA, 1993a.

^a For ozone.^b For CO.^c The periodic inventory requirement is only for ozone nonattainment areas.^d Definition of major and significant net emissions increase depends on pollutant (e.g., for ozone it depends on an area's classification).^e Additional nonmajor sources may be added by EPA rule expected in late 1990s.^f Applicability determination is based on emissions of all pollutants regulated under the Act. However, emission inventory submitted to the state is generally on pollutants listed to determine control technology requirements.

CMS = Continuous Monitoring System.

NADB = National Allowance Database.

ARDS = Acid Rain Data System.

TRAC = Tracking Responses to Acid Rain Compliance.

NA = Not applicable.

TABLE 1.2-2

COMPARISON OF EMISSIONS REPORTING PROGRAM DATA ELEMENTS

Data Element	Triennial Inventory (State to EPA)	AIRS Annual Update (State to EPA)	Permit Program ^a (Source to State)	Emission Statement (Source to State)
Plant - General Level				
FIP State Code	✓	✓	✓	✓
FIP County Code	✓	✓	✓	✓
Year of Record	✓	✓	✓	✓
Plant AFS/NEDS ID	✓	✓	✓	✓
Plant Name	✓	✓		✓
Plant Address	✓	✓	✓	✓
FIP City Code	✓	✓	✓	✓
Plant Zip Code	✓	✓	✓	✓
UTM Zone, Easting, and Northing or Latitude and Longitude	✓	✓		✓
Primary SIC Code	✓	✓	✓	✓
Type of Inventory	✓			
Annual Nonbanked Emissions (Estimated Actual)			✓	
Point - General Level				
FIP State Code	✓	✓		✓
FIP County Code	✓	✓		✓
Plant AFS ID	✓	✓		✓
Point AFS ID	✓	✓		✓
Operating hours/day	✓	✓		✓
Operating days/week	✓	✓		✓

TABLE 1.2-2

(CONTINUED)

Data Element	Triennial Inventory (State to EPA)	AIRS Annual Update (State to EPA)	Permit Program^a (Source to State)	Emission Statement (Source to State)
Operating hours/year	✓	✓		✓
Percent throughput: Dec-Feb	✓	✓		✓
Percent throughput: Mar-May	✓	✓		✓
Percent throughput: Jun-Aug	✓	✓		✓
Percent throughput: Sep-Nov	✓	✓		✓
Stack Level				
FIP State Code	✓	✓		
FIP County Code	✓	✓		
Plant AFS ID	✓	✓		
Stack AFS ID	✓	✓		
Stack Height	✓	✓		
Stack Diameter	✓	✓		
Plume Height	✓	✓		
Segment - General Level				
FIP State Code	✓	✓		✓
FIP County Code	✓	✓		✓
Plant AFS ID	✓	✓		✓
Point AFS ID	✓	✓		✓
Segment AFS ID	✓	✓		✓
SCC Number	✓	✓		✓
Process Rate Units	✓			✓
Actual Annual Process Rate	✓			✓

TABLE 1.2-2

(CONTINUED)

Data Element	Triennial Inventory (State to EPA)	AIRS Annual Update (State to EPA)	Permit Program ^a (Source to State)	Emission Statement (Source to State)
Ozone Season Daily Process Rate	✓			✓
CO Season Daily Process Rate	✓			
Stack ID for Segment	✓			
Segment - Pollutant Level				
FIP State Code	✓	✓	✓	✓
FIP County ID	✓	✓	✓	✓
Plant AFS ID	✓	✓	✓	✓
Point AFS ID	✓	✓		✓
Segment AFS ID	✓	✓		✓
Pollutant/CAS Number	✓	✓	✓	✓
Primary Control Device Code	✓	✓		✓
Secondary Control Device Code	✓	✓		✓
Control Efficiency	✓	✓		✓
SIP Regulation in Place	✓			
Compliance Year for Segment	✓			
Emission Limitation Description	✓			
Emission Limitation Value	✓			
Emission Limitation Units	✓			
Emission Estimation Method	✓	✓		✓

TABLE 1.2-2**(CONTINUED)**

Data Element	Triennial Inventory (State to EPA)	AIRS Annual Update (State to EPA)	Permit Program^a (Source to State)	Emission Statement (Source to State)
Emission Factor	✓	✓		✓
Annual Nonbanked Emissions (Estimated Actual)	✓	✓		✓
Rule Effectiveness	✓			✓
Ozone Season Daily Emissions	✓			✓
CO Season Daily Emissions	✓			

Source: EPA, 1992e.

^a Proposed AFS permit enhancements.

quality relative to the NAAQS. For those areas meeting the standard, the state is required to submit plans showing prevention of significant deterioration (PSD).

For nonattainment areas, the state must develop and submit to EPA a detailed, comprehensive and legally binding plan to meet the NAAQS by a specified date and to continue to meet the NAAQS beyond that date. This legally binding plan is called a state implementation plan (SIP). In the SIP, each state has the responsibility for selecting a control strategy that determines which sources must control emissions and the degree of control needed to achieve and/or maintain the NAAQS. States that have been totally or partially designated as nonattainment areas must develop emissions inventories as part of their SIP to reduce emissions. If the state fails to submit an adequate plan, the EPA will impose its own plan, called a federal implementation plan (FIP).

In addition to those requirements related to maintenance of the NAAQS, other federal-state programs addressing emissions of various air pollutants have also been established to improve air quality. These include emissions standards for hazardous air pollutants (HAPs), emission and fuel standards for motor vehicles, provisions for control of acid deposition, requirements for operating permit programs, and stratospheric ozone protection. The following sections briefly describe these programs.

SIP Requirements (CAA Amendments, Title I)

The CAA requires that the base year SIP inventories be prepared according to a set of minimum standards. The requirements for ozone and CO SIP inventories are listed in Table 1.2.3.

Operating Permits Program (CAA Amendments, Title V)

Title V of the Clean Air Act mandates that states establish operating permits programs requiring the owners or operators of major and other sources to obtain permits addressing all applicable pollution control obligations under the CAA. These obligations include emissions limitations and standards, and monitoring, recordkeeping, and reporting requirements. Such requirements are to be contained in an operating permit which is issued to the source for a period of no more than five years, before renewal. EPA has published its final regulations on operating permits in a new Part 70 of Title 40 of the *Code of Federal Regulations*. In general, the operating permits program as defined in the Part 70 regulations includes the following sources regulated under the Clean Air Act:

- Major sources of air toxics as defined in Section 112 with the potential to emit 10 tpy or more of any single HAP listed in Section 112(b); or 25 tpy or more of any combination of HAPs; or a lesser quantity if specified by the EPA.

TABLE 1.2-3

INVENTORY REQUIREMENTS OF THE CLEAN AIR ACT AMENDMENTS FOR OZONE AND CO

Activity	Requirement	Date
Ozone Base Year Inventory--Basis For All Other Inventories	<ul style="list-style-type: none"> • Comprehensive, accurate inventory for 1990 • Include VOC, NO_x, and CO from point, area, and mobile sources • Include anthropogenic and biogenic sources • Same requirements for all nonattainment classifications 	11/15/92
Adjusted Ozone Base Year Inventory	<ul style="list-style-type: none"> • Needed to demonstrate 15% VOC reduction by 1996 • Excludes biogenic emissions and emissions reductions required before CAAA 	11/15/93
CO Base Year Inventory	<ul style="list-style-type: none"> • Comprehensive, accurate inventory for 1990 • Include CO emissions from point, area, and mobile sources for a 24-hour period • For moderate and serious areas 	11/15/92
PM ₁₀	<ul style="list-style-type: none"> • Comprehensive, accurate inventory due with the attainment plan • Most significant inventory will be for serious areas--due later 	11/15/92
Inventory Work Plan	<ul style="list-style-type: none"> • The EPA requires states to submit plans to explain how they will develop, document, and submit their inventories 	10/01/91

TABLE 1.2-3

(CONTINUED)

Activity	Requirement	Date
Periodic Inventories for Ozone and CO	<ul style="list-style-type: none"> • Same information as base year • 1993 base for first year • Purpose is to track emissions reductions for all nonattainment classifications 	Ozone - 11/15/96 CO-09/30/95 Update every 3 years until attainment
Ozone Modeling Inventory	<ul style="list-style-type: none"> • Required for all areas using photochemical grid model and other moderate areas making an attainment demonstration • Requires base year and projected inventory • Photochemical grid model requires allocated, speciated, and spatially gridded inventory 	Areas using a photochemical grid model--inventory due 11/15/94. Other modeling approaches--inventory due 11/15/93.
CO Modeling	<ul style="list-style-type: none"> • Needed for nonattainment areas with design values exceeding 12.7 ppm • Requires base year and projected inventory • Detail will reflect model used (proportional rollback or gridded dispersion model) • Used for determining whether proposed SIP control strategies are adequate to reach attainment by specified date. • Moderate areas demonstration plan for attainment. • Serious areas demonstration plan for attainment. 	11/15/93 12/31/95 12/31/00

TABLE 1.2-3**(CONTINUED)**

Activity	Requirement	Date
RFP Projection Inventory for 3% per year VOC Reduction	<ul style="list-style-type: none"> • Serious and above areas show 3% per year VOC reduction after 1996 • Continue until attainment • Base year will be final year of demonstration (i.e., 1999, 2002, 2005, 2008, 2010) • Based on allowable emissions reflecting regulatory limits 	11/15/94
Emission Statements	<ul style="list-style-type: none"> • For all nonattainment classifications • Annual statements from owners of stationary sources showing actual emissions of NO_x or VOCs • Certify information is accurate • Sources less than 25 tpy can be waived if included in inventory and the EPA emission factors used 	11/15/93

- Any other source, including an area source, subject to the HAP provisions of Section 112. An area source is any source not considered to be a major source.
- Major sources in nonattainment areas as defined in Part D of Title I with potential to emit pollutants in the amounts shown in Table 1.2-4.
- Any source subject to the new source performance standards (NSPS) under Section 111.
- Sources subject to the preconstruction permits requirements of the Prevention of Significant Deterioration (PSD) program under Title I, Part C or the nonattainment area NSR program under Title I, Part D.
- Major sources as defined in Section 302 of the Act with the potential to emit 100 tpy or more of any pollutant.
- Sources subject to the acid rain provisions contained in Title IV.
- Any source designated by the EPA in whole or in part, by regulation, after notice and comment.

The Part 70 regulations specify the requirements under Title V of the Act for permittees, as well as the administrative duties required of state air permitting agencies. The minimum requirements for information to be submitted by subject sources in the permit application, which include certain emissions-related information, are listed in 40 CFR 70.5(c). Emissions-related information required to be in the application includes the following: (1) all emissions of pollutants for which the source is major [including unregulated Section 112(b) pollutants], and all emissions of regulated air pollutants from all emissions units; (2) identification and description of all emissions points; (3) emissions rate in tpy and in any other units necessary to establish compliance with standards; (4) fuels, fuel use, raw materials, production rates, and operating conditions used to determine emissions, fees, or compliance; (5) pollution control and compliance monitoring activities; (6) limitations on source operation affecting emissions; (7) other relevant information, including stack height limitations; and (8) calculations on which any of the above are based. A state's permit program may also require additional information under its own laws.

TABLE 1.2-4

**EMISSION CUTOFFS FOR DETERMINING APPLICABILITY OF
TITLE V OPERATING PERMITS PROGRAM IN NONATTAINMENT AREAS**

Pollutant	tpy
Ozone (VOC and NO _x):	
Serious nonattainment area	≤ 50
Transport region not severe extreme in nonattainment	≤ 50
Severe nonattainment area	≤ 25
Extreme nonattainment area	≤ 10
Carbon monoxide - serious nonattainment area	≤ 50
Particulate matter - (PM ₁₀) serious nonattainment area	≤ 70

New Source Review (CAA Amendments, Title I)

Section 172(c)(5) of the CAA states that SIPs for nonattainment areas will require preconstruction permits for the construction and operation of new or modified major stationary sources anywhere within the nonattainment area. Likewise, Section 165(a)(1) of the CAA requires that new or modified sources in attainment areas must also secure preconstruction permits. These permits must contain certain basic elements, including legal authority, technical specifications (including an estimate of emissions of each pollutant that the source would have the potential to emit in significant amounts), emission compliance methods, a definition of excess emissions, and other administrative and miscellaneous conditions (EPA, 1992e). Once the source begins operation it will be necessary to determine source emissions under design operating conditions in order to demonstrate compliance or noncompliance with the allowable levels of emissions. Sources obtaining permits for new sources often use trading transactions, which also require emissions estimations.

Emissions Statements (CAA Amendments, Title I)

Section 182(a)(3)(B) of the CAA requires that states with areas designated as nonattainment for ozone obtain emissions statement data from VOC and NO_x sources in the nonattainment areas. Emissions statements are derived from point source data through plant contacts. A revision to a state's SIP to include emissions statements should have been submitted within 2 years of the CAA Amendments enactment date.

The emissions statement requirement applies to all ozone nonattainment areas, regardless of their classification, and to stationary sources that emit, or have the potential to emit, 50 tons per year (tpy) or more of VOC or 100 tpy or more of NO_x in attainment areas within ozone transport regions. A state may, with the EPA's approval, waive the requirement for emissions statements for classes or categories of sources with less than 25 tpy of actual plantwide NO_x or VOC emissions in nonattainment areas if the class or category is included in the base year and periodic inventories and emissions are calculated using emission factors established by the EPA (such as those found in AP-42) or other methods acceptable to the EPA. Whatever minimum reporting level is established, if either VOC or NO_x is emitted at or above this level, the other pollutant should be included in the emissions statement, even if it is emitted at levels below the specified cutoffs.

At a minimum, emissions statements should include: (1) certification of data accuracy, (2) operating schedule, (3) emissions information (to include annual and typical ozone season day emissions), (4) control equipment information, and (5) process data. Agencies are responsible for reviewing the consistency of the emissions statement data with other available data sources and resolving any inconsistencies (EPA, 1992c).

The emissions statement reporting format provides for two data collection mechanisms. Traditional sources (i.e., those with emissions data already in the AIRS database) should review and/or correct their Aerometric Information Retrieval System (AIRS) AFP644 report. Nontraditional sources (i.e., those that do not have emissions data in AIRS) should submit an "Emissions Statement Initial Reporting Form." In both cases, an explanatory letter and detailed instructions should be included. Agencies have the option of developing their own emissions statement reporting format, in which case care should be taken to ensure that the minimum emissions statement data elements are requested and that the emissions statement data are provided to the EPA via the AIRS system.

Facilities must submit their first emissions statement within three years of the CAA Amendments enactment date, and annually thereafter. The first emissions statement will be based on 1992 emissions. The EPA strongly recommends that agencies require a submittal date of April 15 to allow use of the emissions statement data in the preparation of the annual point source inventory. Adequate records of emissions statement data and source certifications of emissions should be maintained by an agency for at least three years to allow for review or verification of the information, as needed.

Agencies should provide the EPA with a status report that outlines the degree of compliance with the emissions statement program. Since July 1, 1993, agencies are required to report the total number of sources affected by the emissions statement provisions, the number that have complied with the emissions statement provisions, and the number that have not. This report is a quarterly submittal until all the regulated sources have complied for the reporting year. The status report also includes the total annual and typical ozone season day emissions from all reporting sources,

both corrected and non-corrected for rule effectiveness. Agencies should include in their status report a list of sources that emit 500 tpy or more of VOC or 2,500 tpy or more of NO_x and that are delinquent in submitting their emissions statements.

Agencies are recommended to enter emissions statement data into AFS by July 1 of each year, as of 1993. This activity should be coordinated with other reporting requirements to avoid deleting valuable data in the AIRS database.

The emissions statement data elements were developed to be consistent with other source and agency reporting requirements. This consistency is essential to assist agencies with an avenue to check emissions estimates and to facilitate consolidation of all EPA reporting requirements. Thus, emissions statement data will provide information useful for the development, quality assurance, and completion of several emissions reporting requirements, including tracking of RFP, periodic inventories, annual AFS submittals, the operating permit program of the CAA, emissions trends, and compliance certifications. The goal of emissions statement reporting in the future is to consolidate all these reporting requirements into one annual effort.

Hazardous Air Pollutants (CAA Amendments, Title III)

Section 112 of the CAA requires EPA to promulgate regulations for reducing the emissions of HAPs. Section 112(b) contains a list of 189 pollutants which are to be regulated as HAPs. Section 112(d) requires that emissions standards be established for each source category listed. A draft schedule for issuance of these standards was published on September 24, 1992 (57 FR 44147) and the emissions standards must be technology-based and must require the maximum achievable degree of reduction possible in emissions of HAPs from the source category. This technology is referred to as maximum achievable control technology (MACT) and the emissions standards are called MACT standards. In general, MACT standards may include process changes; material substitutions; reuse or recycling; enclosure of systems or processes to eliminate emissions; pollution collection, capture or treatment systems; design, equipment, work practice or operational methods; operator training requirements; or a combination of these methodologies.

Section 112 may lead to additional emission estimation or inventory requirements for sources. All sources subject to Section 112 are also subject to the Title V requirements. As such, sources of HAPs must include emissions estimates in their operating permits. In addition, four special programs under Section 112 may lead to additional requirements for emissions estimates. These are: the early reductions program under Section 112(i)(5), the Urban Air Toxics Study under Section 112(k), the Great Lakes and Coastal Waters program under Section 112(m), and the accidental releases program under Section 112(r).

Under Section 112(s), EPA is required to maintain a database on pollutants and sources subject to Section 112. This database will be required to contain information from all of the programs described above, as well as information from standard development projects under

Section 112(d). EPA is planning to consolidate this data into a "MACT database." Information and guidance on this database will be available in future rulemakings pertaining to Section 112.

Early Reduction Program. Under the early reduction program, existing sources may opt to apply for a 6-year extension of the regular 3-year MACT compliance deadline if such sources can demonstrate a 90 percent reduction (or 95 percent reduction for particulate emissions) or more of HAPs prior to the proposal of the applicable MACT standard. As a condition of the compliance extension, states may require additional emission reductions from such sources. Such reductions generally must be based on actual and verifiable emissions in a base year no earlier than 1987. The source must provide a one-time demonstration of the required reduction, which will require estimation and comparison of current emissions and emissions during the relevant base year. It should be noted that the emissions reductions used to qualify under this extension will be federally enforceable, and hence also require a Title V permit revision.

Urban Air Toxics Study. Under the Urban Air Toxics Study, EPA is required to conduct a program of research on sources of HAPs in urban areas. This program must include an analysis to characterize sources of such pollution with a focus on area sources. EPA, in implementing this program, may request specific emissions estimates and other relevant information from sources.

Great Lakes and Coastal Waters Program. Under the Great Lakes and Coastal Waters program (often referred to as the Great Waters Program), EPA is required to assess the extent of atmospheric deposition of HAPs into the Great Lakes, Chesapeake Bay, Lake Champlain, and coastal waters. In addition to numerous monitoring and sampling efforts, this assessment will include an investigation of the deposited chemicals and their precursors and sources. This investigation will likely lead to emissions estimation requirements for sources which emit HAPs that could be deposited into these waters.

Accidental Release Program. Under the accidental release program, sources which emit HAPs above certain threshold quantities must submit risk management plans designed to detect and prevent accidental releases of HAPs. The risk management plan must assess the potential effects of an accidental release, which will include an estimate of potential release quantities, determination of downwind effects, previous release history and an evaluation of the worst case accidental release. The plan must also include an accidental release prevention program and an emergency response program to be implemented in the event of such a release. Such plans must be submitted to EPA, the Chemical Safety and Hazard Investigation Board, and state and local air pollution control agencies.

Section 114 Reporting Requirements, Compliance Certifications and Compliance Monitoring. Section 114 of the CAA gives EPA the authority to require sources to, on a one-time, periodic, or continuous basis, report to EPA information which EPA deems necessary for developing standards or SIPs, determining compliance, or meeting other provisions of the Act. Under Section 114, EPA can require sources to establish recordkeeping; make reports; sample

emissions; keep production, control technology, or other operations data; or provide other necessary information. The EPA may include emissions estimates as part of these information requirements. Information collected under Section 114 is publicly available except non-emissions-related data which may be held as confidential by the EPA, rather than divulging proprietary product information.

Allowance Trading (CAA Amendments, Title IV)

In order to control sources of acid deposition, Title IV of the CAA Amendments establishes the allowance trading program. This program seeks to reduce emissions of SO₂ by 10 million tpy, relative to 1980 levels. Three databases, National Allowance Database (NADB), Acid Rain Data System (ARDS) and Tracking Responses to Acid Rain Compliance (TRAC), are set up under this program to track emissions, allowance trading, and compliance, respectively. Sources affected by Title IV (i.e., those listed in Table A, Title IV, of the CAA Amendments), or those that opt in will be responsible for reporting to these databases. These reports will include general plant information, emissions data, and fuel use data. It should also be noted that sources subject to Title IV requirements are also subject to Title V operating permit provisions (EPA, 1993a).

2.1.2 REQUIREMENTS UNDER OTHER EPA REGULATIONS

A number of other EPA requirements which are not directly related to the CAA require some form of emissions estimation. These requirements are a result of the following federal laws: NEPA, CERCLA, SARA, RCRA, and the Pollution Prevention Act. This subsection briefly highlights these requirements.

National Environmental Policy Act (NEPA) of 1969

The National Environmental Policy Act (NEPA) requires that, where a federal agency action may result in a significant environmental impact, an environmental assessment be prepared before such policy can be implemented. An environmental assessment (EA) is a study that provides background information and preliminary analyses of the potential impact of a new policy. If the results of an EA indicate that significant environmental impact may result, EPA will prepare an Environmental Impact Statement (EIS). The EIS examines, in detail, the potential impact of a proposed agency action. Generally, industries are not required to prepare EISs, but EPA may require industry input, including emissions estimates, for its evaluation of the impact of proposed rulings (EPA, 1993a).

Comprehensive Environmental Recovery and Comprehensive Liability Act of 1980

Under CERCLA, facility managers are required to perform an Air Pathway Analysis (APA) in order to assess the potential for exposure of personnel to toxics in the ambient air at National

Priority List (NPL) sites and to provide input to the Superfund risk assessment process. Air pathway analysis involves a combination of modeling and monitoring methods to assess actual or potential emissions from a hazardous waste site. The APA has three major components: (1) characterization of air emission sources (e.g., estimation of contaminant emission rates) for the control and recordkeeping process; (2) determination of the effects of atmospheric processes (e.g., transport and dilution) on the personnel at a site; and (3) evaluation of receptor exposure potential (i.e., what air contaminant concentrations are expected at receptors of interest for various exposure periods) (EPA, 1989).

Superfund Amendments and Reauthorization Act (SARA) of 1986

SARA, which was passed in 1986 to amend CERCLA, contains two requirements likely to lead to emissions estimation. First, Section 313 of SARA requires that companies that process, manufacture, or otherwise use toxic compounds listed in Section 313 of the Act report to EPA the annual quantities used of those compounds and any releases to the environment (including air emissions) that result from their use. The Section 313 "Right-to-Know" requirements were enacted by Congress to increase public awareness and information on toxic emissions. The EPA has made Section 313 data publicly available. A database has been established, known as the Toxic Release Inventory System (TRIS), which contains information from SARA toxic chemical release reports (EPA, 1993a).

Second, Section 304 of SARA requires that any source which emits amounts in excess of threshold levels of any "hazardous" or "extremely hazardous" substance as defined by EPA pursuant to CERCLA must report the quantities of the substance(s) released. These reports are to be filed with the National Response Center, and are due immediately upon release of the substance (EPA, 1993a).

Resource Conservation and Recovery Act (RCRA) of 1976

RCRA was established to minimize the generation of hazardous waste, and to aid in the management of such hazardous waste. Sections 3001 and 3002 of RCRA require hazardous waste generating facilities to report and analyze their generation of certain hazardous wastes. Such an analysis could include estimation of emissions of certain substances. These facilities must report biennially to EPA.

Pollution Prevention Act of 1990

The Pollution Prevention Act is designed to facilitate the reduction of pollution at the source, rather than to mandate "end-of-pipe" controls. In general, this Act requires several EPA activities to facilitate pollution prevention, including establishing a clearinghouse for pollution prevention information, a grants program, reports to Congress, and others. It also imposes a specific reporting requirement on certain sources. Specifically, sources that are required to file an annual

toxic release form under Section 313 of SARA must also file an annual toxic chemical source reduction and recycling report. Section 6607 of the Pollution Prevention Act describes the specific requirements for this report. For many sources, meeting these requirements will require some form of emissions estimation (EPA, 1991c).

2.1.3 FEDERAL REQUIREMENTS OUTSIDE OF EPA

In addition to EPA, two other federal agencies have requirements that may lead to emissions estimates for certain sources. The Department of Energy (DOE) requires electric power plants to report information on fuels, cooling equipment, environmental control equipment, and other information from which air emissions may be estimated. The Department of Defense (DoD) is in the process of establishing a central air emissions database which is to be part of the Defense Corporate Information Management (DECIM) system. This database may require additional emissions reporting. It should also be noted that each facility subject to any DOE or DoD requirements is also subject to any relevant EPA requirements.

2.2 STATE REQUIREMENTS

As previously described, the EPA places several requirements on states which may indirectly lead to reporting requirements for sources. These include the requirements that the states update emissions inventories on an annual basis for AIRS, that the states submit base year and periodic inventories for SIP development, and that the states develop Title V Operating Permits programs.

Although states must comply with federal requirements, states are not restricted from establishing their own, more stringent requirements. While the federal laws and regulations identify a minimum set of requirements, states may choose to develop additional estimating and reporting requirements. Individual state agencies can provide assistance to sources on identifying and complying with individual state requirements.

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3

EMISSIONS INVENTORY PLANNING

3.1 PRELIMINARY PLANNING ACTIVITIES

Prior to initiating the actual compilation of an emissions inventory, an agency or facility must plan a basic approach for collecting, handling, and reporting emissions data. Careful consideration of the approach to be used in developing the emissions inventory program will greatly facilitate the inventory process and can prevent major revisions to the inventory during review. As part of the preliminary planning activities, the inventory preparer should consider the following:

- End use of the data;
- Scope of the inventory;
- Availability and usefulness of existing data; and
- Strategy for data collection and management.

Each of these issues is discussed in more detail below.

3.1.1 END USE OF THE DATA

A basic consideration in planning the inventory is establishing the end uses of the completed inventory. For the regulatory agency, the end uses of all inventories fall into three general categories: (1) air quality control strategy development, (2) air quality maintenance, and (3) air quality research. For an individual facility, the inventory may be the measure of progress towards a corporate goal for emission reductions and/or a means of identifying opportunities for process improvements. Possible future use of the inventory, as well as immediate objectives, should be considered in determining inventory procedures and data needs.

3.1.2 SCOPE OF THE INVENTORY

In defining the scope of the inventory, the primary considerations are the desired level of detail, the desired number of sources, and the pollutant(s) of interest. Point sources can be inventoried at three levels of detail: (1) the plant level, which denotes a plant or facility that could contain several pollutant-emitting activities; (2) the point/stack level, where emissions to the ambient air from stacks, vents, or other points of emission are characterized; and (3) the process/segment

level, representing the unit operations of specific source categories. The appropriate level of detail will be a function of the intended use of the data.

Under ideal circumstances, all stationary sources would be considered point sources for purposes of emission inventories. In practical applications, however, only sources that emit more than a specified cutoff level of pollutant are considered point sources. In general, the higher the cutoff level, the fewer the facilities that are included in an inventory of point sources; a lower cutoff level would result in the inclusion of more sources. As a rule, the lower the cutoff level, the greater the cost to develop the inventory. However, a low cutoff level will increase user confidence in the source and emissions data, and the inventory will have a greater number of applications.

The pollutants to be inventoried are a major element in determining the scope of the inventory. The pollutants of interest for ozone inventories are VOCs, NO_x, and CO. For other criteria pollutants, only the criteria pollutant itself is of interest in the inventory. For HAP inventories on the federal level, the CAA list of 189 HAPs determines the pollutants to be inventoried.^a States and local agencies may have additional toxic pollutants on their state/local toxic air pollutant (TAP) lists.

Table 1.3-1 presents source categories that should be considered for inclusion in point source emission inventories. The table also indicates the types of pollutants emitted from these categories. In defining the scope of an inventory, the emphasis should be on those source categories that are located in the geographic area covered by the inventory and that are addressed by regulations applicable to point sources. The selected sources and source categories should be compatible with available information and be of sufficient detail to facilitate control strategy projections.

3.1.3 AVAILABILITY AND USEFULNESS OF EXISTING DATA

A major inventory planning consideration is whether, and to what extent, existing information can be used. Existing inventories should be examined to determine whether the appropriate sources have been included and whether the emissions data represent current conditions. Existing inventories can serve as a starting point for developing extensive data and support information, such as documentation of procedures. Information may also be drawn from other regulatory agency operations such as permitting, compliance, and source inspections and from

^aCaprolactam was delisted as a HAP (*Federal Register*, Vol. 61, page 30816, June 18, 1996).

TABLE 1.3-1

POTENTIAL POINT SOURCES AND POLLUTANTS

Source Name	Description	POLLUTANTS						
		VOC	CO	NO _x	SO ₂	PM ₁₀	Lead	HAPs
Fuel Combustion, Electric Utilities	Coal			X	X	X	X	X
	Oil			X	X	X	X	X
	Gas			X				X
	Other						X	
	Internal Combustion							X
Fuel Combustion, Industrial	Coal			X	X	X	X	X
	Oil			X	X	X	X	X
	Gas			X		X		X
	Other			X		X	X	
	Internal Combustion							X
Fuel Combustion, Other	Commercial/Institutional Coal			X	X	X	X	X
	Commercial/Institutional Oil			X	X	X	X	X
	Commercial/Institutional Gas			X				X
	Misc. Fuel Comb. (Except Residential)						X	X
	Residential Wood	X	X			X		
	Residential Other			X	X			X
Chemical and Allied Product Mfg.	Organic Chemical Mfg.	X	X					X
	Inorganic Chemical Mfg.		X				X	X
	Polymer and Resin Mfg.	X						X
	Agricultural Chemical Mfg.							X
	Paint, Varnish, Lacquer, Enamel Mfg.	X						X
	Pharmaceutical Mfg.	X						X
	Other Chemical Mfg.	X	X					X

TABLE 1.3-1

(CONTINUED)

Source Name	Description	POLLUTANTS						
		VOC	CO	NO _x	SO ₂	PM ₁₀	Lead	HAPs
Metals Processing	Non-Ferrous Metals Processing		X		X	X	X	X
	Ferrous Metals Processing	X	X			X	X	X
	Metals Processing Not Else Classified (NEC)						X	X
Petroleum and Related Industries	Oil and Gas Production	X			X			X
	Petroleum Refineries and Related Industries	X	X		X	X		X
	Asphalt Manufacturing	X				X		X
Other Industrial Processes	Agriculture, Food, and Kindred Products	X				X		X
	Textiles, Leather, and Apparel Products	X				X		X
	Wood, Pulp and Paper, and Publishing Products	X	X			X		X
	Rubber and Miscellaneous Plastic Products	X						X
	Mineral Products			X	X	X	X	X
	Machinery Products					X		X
	Electronic Equipment					X		X
	Transportation Equipment					X		X
	Construction					X		X
	Miscellaneous Industrial Processes	X				X		X
Solvent Utilization	Degreasing	X						X
	Graphic Arts	X						X
	Dry Cleaning	X						X
	Surface Coating	X						X
	Other Industrial	X						X
	Nonindustrial	X			X			X

TABLE 1.3-1

(CONTINUED)

Source Name	Description	POLLUTANTS						
		VOC	CO	NO _x	SO ₂	PM ₁₀	Lead	HAPs
Storage and Transport	Bulk Terminals and Plants	X			X			X
	Petroleum and Petroleum Product Storage	X						X
	Petroleum and Petroleum Product Transport	X						X
	Service Stations: Stage I	X						X
	Service Stations: Stage II	X						X
	Service Stations: Breathing and Emptying	X						X
	Organic Chemical Storage	X						X
	Organic Chemical Transport	X						X
	Inorganic Chemical Storage					X		X
	Inorganic Chemical Transport					X		X
	Bulk Materials Storage					X	X	X
	Bulk Materials Transport					X	X	X
Waste Disposal and Recycling	Incineration		X			X	X	X
	Open Burning	X	X			X		X
	Publicly Owned Treatment Works (POTW)	X						X
	Industrial Waste Water	X						X
	Treatment, Storage, and Disposal Facility (TSDF)	X				X		X
	Landfills	X				X		X
	Other	X				X	X	X
Miscellaneous	Agriculture and Forestry			X		X		X
	Other Combustion	X	X			X		X
	Catastrophic/Accidental Releases	X			X	X		X
	Repair Shops	X						X
	Health Services	X						X
	Cooling Towers	X						X
	Fugitive Dust					X		X

other facility resources such as corporate reporting or compliance report submittals. For effective use of resources, an agency or facility should plan to fulfill specific emissions inventory requirements by building upon and improving the quality of regularly collected data.

For effective use of resources, an agency or facility should plan to fulfill specific emissions inventory requirements by building upon and improving the quality of regularly collected data.

3.1.4 STRATEGY FOR DATA COLLECTION

Another key decision in inventory planning regards what particular data collection procedures will be followed. Alternatives include questionnaires, plant inspections, and review of existing agency permit and compliance files. Depending on the approach selected, the data available may be in various forms such as source tests, material balances, purchasing records, or actual emission estimates. The amount of staff and budget that will be needed to actually gather the data and then manipulate it into the desired inventory will also vary depending on the selected approach. The inventory preparer must keep these considerations in mind during the preliminary planning phase in order to decide on the strategy that best matches the data needs and the available resources.

Because it is not always certain whether a category will be considered a point or an area source for the purpose of the inventory, data collection efforts should always include as much detailed information as possible. For example, employment by standard industrial classification code may not be used in a point source inventory, but would be helpful for preparing an area source inventory.

Once the strategy for data collection is known, the inventory preparer needs to consider how these data will be handled and managed, including QA/QC procedures. Emissions inventory data for a single point source or area source category may be minimal enough to be handled using spreadsheets or by hand calculations. For large sets of data, some type of electronic database will be needed to organize, manipulate, and simply store the collected data. There are a wide variety of available software packages designed for the tracking of environmentally related emissions and release information. The system used should be able to handle the types of information being collected as well as have the ability to export information for state and federal reporting requirements.

3.2 INVENTORY WORK PLAN

The inventory work plan is a concise, to-the-point document that declares how an agency or plant intends to develop and present its inventory. It allows a line of communication between the inventory preparer, his/her management, and the receiving agency to ensure that the inventory is conducted effectively. The work plan should include inventory objectives and general procedures and should address all sources (regardless of size) of all the target pollutants.

Although no specific format is usually required, the work plan should, at a minimum:

- Define how the inventory work plan is structured and what it contains;
- Define the inventory area by nonattainment status;
- Provide the background/basis for the inventory (i.e., previous efforts that are viable and related);
- Specify who is responsible for the inventory, with a detailed organization chart of key personnel/consultants;
- Specify the quality assurance (QA) coordinator (who must be different than the inventory management or technical staff);
- Describe the approach to be used to estimate emissions, including plans for data collection, analysis, and storage; and
- Describe how the plant or agency plans to present and document the inventory for submittal.

For point sources, an agency must define how all pertinent emissions sources will be identified and located. The work plan should describe how point source activity levels and associated parameters will be developed, and how these data are used to calculate emissions estimates. It should also describe the type of source surveys that are planned and the use of existing data contained in systems such as the Aerometric Information Retrieval System (AIRS), state emission inventory systems, or state permitting files.

3.3 TRAINING

Training is an important component of the facility's or agency's preliminary planning activities. The extent of training needed will depend on the staff chosen to prepare the inventory and the number of new procedures required by the inventory process.

Training courses for the critical components of an emissions inventory are provided annually by the EPA's Air Pollution Training Institute (APTI). These courses provide detailed instruction in:

- Inventory planning;
- Inventory management;
- Point source emissions;

- Emissions calculations;
- Projection techniques; and,
- Data reporting.

These courses are available to any individuals with the education, experience, or employment responsibilities involving enforcement or compliance with regulatory programs for achievement of air quality standards. Further information can be obtained by contacting the APTI (see Appendix C).

3.4 DATA HANDLING

Inventory data can be managed almost entirely by computer. During the inventory planning stages, the inventory preparer should anticipate the volume and types of data-handling needed in the inventory effort and should weigh the relative advantages of manual versus computerized systems. If the inventory preparer must deal with large amounts of data, maximizing the use of computerized inventory data-handling systems will allow them to spend more time gathering, analyzing, and validating the inventory data, as opposed to manipulating the data.

Computerized data handling becomes significantly more cost-effective as the database, the variety of tabular summaries, or the number of iterative tasks increases. In these cases, the computerized inventory requires less overall time and has the added advantage of forcing organization, consistency, and accuracy.

Some activities that can be performed efficiently and rapidly by computers include:

- Printing mailing lists and labels;
- Maintaining status reports and logs;
- Calculating and summarizing emissions;
- Performing error checks and other audit functions;
- Storing source, emissions, and other data;
- Sorting and selectively accessing data; and
- Generating output reports.

Additional information on data handling is presented in Volume VII of the EIIP series of guidance documents.

3.5 DOCUMENTATION REQUIREMENTS

Documentation is an integral part of an emissions inventory. Before submittal, internal review of the written documentation provides an opportunity to uncover and correct errors in assumptions, calculations, or methods. Following submittal of the inventory, the documentation allows the results of the inventory to be clearly understood and the quality of the inventory to be effectively judged.

Although documentation requirements may evolve during data collection, the calculation and reporting steps of the emissions inventory development process should be anticipated during planning. Planning the level of documentation required will: (1) ensure that important supporting information is properly developed and maintained; (2) allow extraneous information to be identified and discarded, thereby reducing the paperwork burden; (3) help determine data storage requirements; and (4) aid in identifying aspects of the inventory on which to concentrate the QA efforts.

3.6 SCHEDULE

If the development and maintenance of an emissions inventory is conceptualized as a network of activities or events with a definite start and end, various techniques can be used to formulate a project schedule. One method is to graphically present the inventory tasks, their estimated completion times, major project milestones, and labor requirements. This is a useful way to visualize the activities and their relationships to one another. By identifying the "critical path" events at this early point in the schedule-planning activities, the inventory preparer can anticipate potential bottlenecks in the process and avoid delays that might affect the timely submittal of the final inventory.

It is important to remember that a schedule must be frequently compared to the actual progress of the inventory effort. By closely tracking the activities, the preparer can: (1) ensure that each task is being completed expeditiously; (2) revise labor commitments to reflect schedule and data changes; and (3) learn from experience so that this knowledge can be applied towards future inventory efforts.

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4

EMISSION ESTIMATION PROCEDURES

Air pollutant emissions may be released from numerous sources within a facility. Depending on the facility size, the nature and number of processes, and the emission control equipment in place, emission estimation may be very simple or extremely difficult. The inventory preparer should consider the types of emissions to be reported (i.e., actual, potential, or allowable), the availability of data, and the cost when selecting which method of emissions estimation is appropriate.

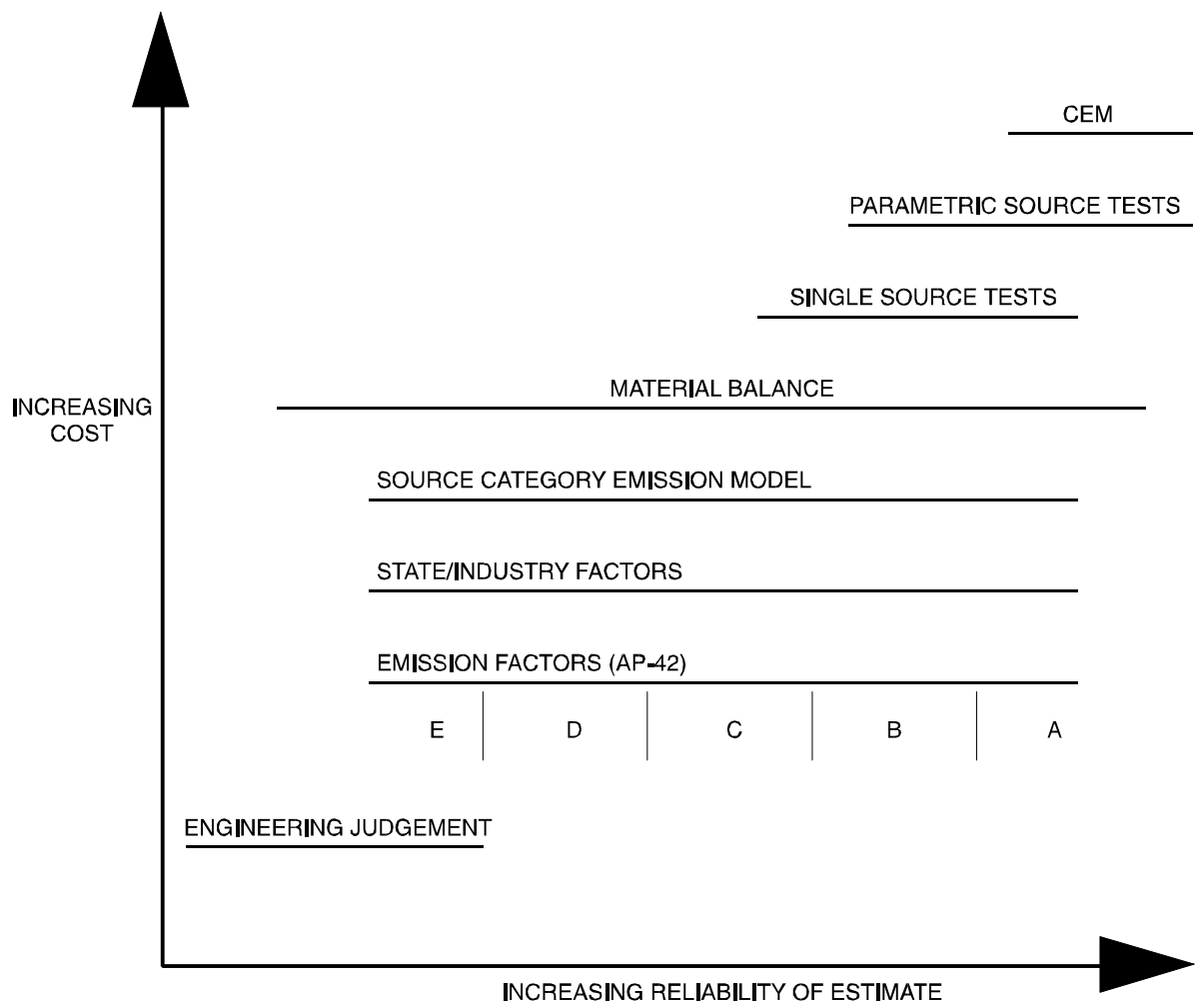
Figure 1.4-1 (from *AP-42*) depicts various approaches to emission estimation that should be considered when analyzing the costs versus the quality of the results (EPA, 1995a). Ideally, plants needing emissions estimates would use continuous emissions monitoring (CEM) to obtain actual emissions measurements over very short time intervals. Some facilities currently do this. The CEM concentration data can be easily converted to mass emission rates provided the air volume through the monitor is also known. In cases where CEM or parametric monitoring data are unavailable, however, another method must be used to estimate emissions. The three principal methods for estimating emissions in such cases are source tests, material balances, and emission factors. If none of these three methods can be employed to estimate emissions for a specific process, an approximation or engineering estimate based on available process, physical, chemical, and emission knowledge may be used.

Where risks of adverse environmental or regulatory effects are high, the more sophisticated and costly emission determination methods such as CEM or source tests may be necessary. Conversely, where the risks are low, less expensive estimation methods such as the use of emission factors and emission models may be acceptable.

4.1 SOURCE TESTS

The source test is a common method of estimating process emissions. Source tests are short-term emission measurements taken at a stack or vent. Due to the substantial time and equipment involved, a source test requires more resources than an emission factor or material balance emission estimate. Typically, a source test uses two instruments: one to collect the pollutant in the emission stream and one to measure the emission stream flow rate. The essential difference between a source test and CEM is the duration of time over which

RISK SENSITIVITY EMISSION ESTIMATION APPROACHES



measurements are conducted. A source test is conducted over a discrete, finite period of time, while CEM is continuous.

If the use of source test data reduces the number of assumptions regarding the applicability of emissions data to a source (a common consideration when emission factors are used), as well as the control device efficiency, equipment variations, and fuel characteristics. Thus, source tests typically provide better emission estimates than emission factors or material balances, if correctly applied (Southerland, 1991). However, source test data should be used for emission estimation purposes only if the data were obtained under conditions which are representative of or related to operating conditions normally encountered at the source in question.

Two items should be noted when using source test data to calculate emissions. First, because most source tests are only conducted over several hours or days at most, adjustments may need to be made when using these data to estimate emissions over longer time intervals. Emission data from a one-time source test can be extrapolated to estimate annual emissions only if the process stream does not vary and if the process and control devices are operated uniformly.

Second, a source test may not adequately describe a given facility's annual or seasonal operating pattern. For example, there may be variations in process operation throughout the year or the efficiency of control device performance may vary due to fluctuations in ambient temperature or humidity. In such cases, multiple tests must be conducted for source testing to be useful in generating an emission estimate for extended periods that are longer than the test period. If facility operation and test methods employed during the source test cannot be adequately characterized, the source test data should not be used.

If a source test is used to estimate emissions for a process, test data gathered on-site for that process is generally preferred. The second choice is to use test data from similar equipment and processes on-site, or to use pooled source tests or test data taken from literature. The reliability of the data may be affected by factors such as the number of tests conducted and the test methodology used.

The EPA has published reference methods for measuring emissions of PM, SO₂, NO_x, CO, and VOC. The reference methods, given in Title 40, Code of Federal Regulations, Part 60, Appendix A, define and describe the test equipment, materials, and procedures to be used in stack tests for the various criteria pollutants. Reference methods for estimating HAP emissions are published in Title 40, Code of Federal Regulations, Part 61, Appendix B (EPA, 1986; EPA, 1988). The EPA publication, *Screening Methods for the Development of Air Toxics Emission Factors*, presents an overview of the use of these reference methods for specific HAPs (EPA, 1992d). A brief description of several EPA methods is given in Appendix E. For further information, the reader can consult with the Emission Measurement Technical Information Center (EMTIC), which provides technical guidance on stationary source emission testing. Industry personnel may access EMTIC on the EPA's Technology Transfer Network bulletin board system,

or by calling EMTIC staff directly. Appendix C contains EMTIC contact information.

Most source test reports summarize emissions for each pollutant by expressing them in terms of: (1) a mass loading rate (weight of pollutant emitted per unit of time); (2) an emission factor (weight of pollutant emitted per unit of process activity); or (3) a flue gas concentration (weight or number of moles of pollutant per some weight or volume of flue gas). Generally, when a mass loading rate or flue gas concentration is provided, the resulting emission factor can easily be calculated with knowledge of equipment size or operating parameters, as in the example below (EPA, 1993a):

- Example. A single-line paper coating plant has been subjected to an emission test for VOC emissions. Since the coating solvent is primarily toluene, the emission concentrations were measured as toluene. The data averaged for three test runs are as follows:

Stack flow rate (Q_s)	= 10,000 scf
Emission concentration (C_e)	= 96 ppm (as toluene)
Fugitive emission capture (Eff_{cap})	= 0.90 (90 percent, as required by reasonably available control technology (RACT))

Other information needed to complete the calculations include:

Plant operation	= 16 hour/day, 312 days/year
Solvent input rate (M_i)	= 500 ton/year
Rule effectiveness (RE)	= 0.80 (80 percent)
Molecular weight (toluene)	= 92
Unit correction factor (f)	= 1.58×10^{-7} (lb-mole-min)/(hr-ppm-scf)

The emission calculation begins with determination of the average mass loading rate (M_o):

$$\begin{aligned}
 M_o &= (f)(MW)(C_e)(Q_s) \\
 &= (1.58 \times 10^{-7})(92)(96)(10,000) \\
 &= 14 \text{ lb/hr}
 \end{aligned}$$

The emission control efficiency (Eff_{con}) is calculated:

$$\begin{aligned}
 Eff_{con} &= (M_i - M_o)/M_i \\
 &= [500 - ((14)(16)(312)/2,000)]/500 \\
 &= 0.93 \text{ (93 percent control)}
 \end{aligned}$$

4.2 MATERIAL BALANCES

The material balance (also known as a mass balance) is a method commonly used for estimating emissions from many source categories. In this method, emissions are estimated as the difference between material input and material output across a vessel, process, or entire facility. The material balance method can be used where source test data, emission factors, or other developed methods are not available. For example, emissions from evaporation sources are commonly estimated using this approach as are sources where testing of low-level, intermittent, or fugitive exhaust streams would be very difficult, costly, and uncertain. The material balance is most appropriate to use in cases where accurate measurements can be made of all but the air emission component, or when the emission estimate will be used for screening purposes if reasonable assumptions can be made about the fate of compounds.

Use of material balances involves the examination of a process to determine whether emissions can be estimated solely on knowledge of operating parameters, material compositions, and total material usage. The simplest material balance assumes that all solvent used in a process will evaporate to become air emissions somewhere at the facility. For instance, for many surface coating operations, it can be assumed that all of the solvent in the coating evaporates to the atmosphere during the application and drying processes. In such cases, emissions equal the amount of solvent contained in the surface coating plus any added thinners.

Material balances are greatly simplified and very accurate in cases where all of the consumed solvent is emitted to the atmosphere. But many situations exist where a portion of the evaporated solvent is captured and routed to a control device such as an afterburner (incinerator) or condenser. In these cases, the captured portion must be measured or estimated by other means and the disposition of any recovered material must be accounted for. As a second example, in degreasing operations, emissions will not equal solvent consumption if waste solvent is removed from the unit for recycling or incineration. A third example is cutback asphalt paving where some fraction of the diluent used to liquefy the asphalt is believed to be retained in the substrate (pavement) rather than evaporated after application. In these examples, a method of accounting for the non-emitted solvent is required to avoid an overestimation of emissions.

Material balances cannot be accurately employed at a reasonable cost for some evaporation processes because the amount of material lost is too small to be determined accurately. As an example, applying material balances to petroleum product storage tanks is not generally feasible because the losses are too small relative to the uncertainty of any metering devices. In these cases, *AP-42* emission factors or equations can be used (EPA, 1995a).

The material balance method should not be used for processes where material is reacted to form products or where the material otherwise undergoes significant chemical change. If a material balance method is used to estimate emissions and if the actual emissions are a small fraction of the throughput, the throughput estimate or measurement can be even more critical. Because the

emissions are estimated to be the difference between the material input and the known material output, a small percentage error in estimating the input or output can result in a much larger percentage error in the emission estimate. For this reason, material balances are sometimes inappropriate for estimating small losses.

Available test methods are published through the American Society for Testing and Materials (ASTM) and have focused on providing information on material balance and gravimetric determinations for various industrial processes (ASTM, Volumes 06.01 and 15.05). The use of a mass or material balance to determine total emissions from a process is usually simple and affordable. Total VOC emitted from a batch paint mixing process, for example, would be calculated as follows (according to ASTM Method D 2369):

$$\text{VOC}_{\text{added to mixing vessel}} (\text{lb/gal}) - \text{VOC}_{\text{in final paint mixture}} (\text{lb/gal}) = \text{VOC}_{\text{emitted}} (\text{lb/gal}) \quad (1.4-1)$$

4.3 EMISSION FACTORS

One of the most useful tools available for estimating emissions from point sources is the emission factor. An emission factor is a ratio that relates the quantity of a pollutant released to the atmosphere to the activity level associated with the release of that pollutant (e.g., production rate or amount of fuel combusted). If the emission factor and the corresponding activity level for a process are known, an estimate of the emissions can be made. In most cases, emission factors are expressed simply as a single number, with the underlying assumption that a linear relationship exists between emissions and the specified activity level over the probable range of application. The use of emission factors is straightforward when the relationship between process data and emissions is direct and relatively uncomplicated. The primary reference for criteria pollutant emission factors for industrial sources is *AP-42* (EPA, 1995a).

Because emission factors are averages obtained from data of wide range and varying degrees of accuracy, emissions calculated this way for a given facility are likely to differ from that facility's actual emissions; factors will indicate higher emission estimates than are actual for some sources, and lower for others. Only specific source measurement can determine the actual pollutant contribution from a source, under conditions existing at the time of the test. For the most accurate emissions estimate, it is recommended that source-specific data be obtained whenever possible. If factors are used to predict emissions from new or proposed sources, the latest literature and technology should be reviewed to determine whether such sources would likely exhibit emission characteristics different from those sources from which the emission factors were derived.

In addition to presenting emission factors, *AP-42* gives a quality indicator for each emission factor rated "A" through "E," with "A" being the best; and U1 through U5, published with varying degrees of uncertainty (EPA, 1995a). The lower the quality indicator, the more likely that a given emission factor may not be representative of the source type. When an emission factor for a

specific source or source category may not provide a reasonably adequate emission estimate, it is always better to rely on actual stack test data, where available. Conversely, if an emission factor does provide reasonably adequate emission estimates, stack testing may represent an ineffective use of time and resources.

The EPA continues to update and expand the factors in *AP-42*, including a more detailed speciation of VOC and other organic emissions by compound or compound class, where data are available (EPA, 1995a). The EPA databases and documents that contain emission factors for use in inventory development are discussed in more detail in Appendix F. The EPA's procedure for assigning emission factor quality ratings is described in the document, *Technical Procedures for Developing AP-42 Emission Factors and Preparing AP-42 Sections* (EPA, 1993b).

4.3.1 CALCULATION OF EMISSIONS USING EMISSION FACTORS

In order to calculate emissions using emission factors, various inputs to the estimation algorithm are required:

- Activity information for the process as specified by the relevant emission factor;
- Emission factors to translate activity information into uncontrolled or controlled emission estimates; and
- Capture device and control device efficiencies to provide the basis for estimation of emissions to the atmosphere after passage through the control device(s) if using an uncontrolled emission factor ("Controlled" emission factors already take this into account).

The basic emission estimation algorithm for an uncontrolled emission factor is:

$$E = A * EF * (1 - ER/100) \quad (1.4-2)$$

where:

E	=	emission estimate for source (at the process level)
A	=	activity level (such as throughput)
EF	=	"uncontrolled" emission factor (such as lb emitted/throughput)
ER	=	overall emission reduction efficiency, expressed in percent; equal to the capture device efficiency multiplied by the control device efficiency

If a controlled emission factor is being used, the emission factor already incorporates the control system effectiveness term $(1 - ER/100)$; therefore, the form of the algorithm is:

$$E = A * EF \quad (1.4-3)$$

where:

E	=	emission estimate for source (at the process level)
A	=	activity level (such as throughput)
EF	=	controlled emission factor (such as lb emitted/throughput)

The accuracy of the emission estimate is equally dependent upon the relative accuracy of each of these individual components. Errors introduced into any one of these components will affect the final emission estimate.

4.3.2 ROLE OF THROUGHPUT IN EMISSION FACTOR ESTIMATES

The activity level (also referred to as throughput rate) is the second component of an estimate developed using an emission factor. For industrial processes, activity data are generally reported as process weight rates (e.g., pound, ton, gallon or barrel per hour). Similarly, for fuel-burning equipment, activity data are reported as fuel consumption rates (tons, 10^3 gallons, 10^6 ft³, or 10^6 Btu per hour). The optimum activity data are hourly values, although in some cases only shift, daily, weekly or even monthly data are available. If hourly values are not known, the hourly average value can be calculated from the actual operating schedule.

In many instances, conversion factors must be applied to convert reported consumption or production values into units that correspond to the emission factor throughput units (tons, barrels, etc.). For example, an emission factor for fuel oil consumption may be given in lbs per MMBtu while the activity data are available only in gallons of oil per hour. In order to estimate emissions, a conversion factor is needed. The heating value of the fuel in MMBtu per gallon provides the necessary conversion. In this case, the emission equation would be:

$$E = A \times EF \times C \quad (1.4-4)$$

where:

E	=	emission estimate in lbs/hr
A	=	activity level = fuel consumption in gal/hr
EF	=	emission factor in lbs/MMBtu
C	=	conversion factor = heating value in MMBtu/gal

If the emission factor or activity data involve electrical power output or steam generation, an additional correction factor (i.e., the fractional efficiency of the fuel burning equipment) must be applied to account for conversion of heat input to power output (electrical) or steam production (thermal).

Occasionally, additional process data are required to ensure that the correct conversion factors are applied. For example, a production rate for plywood boards might be given as the number of boards manufactured per hour, while an emission factor relates emissions to the number of tons manufactured, rather than the number of boards. In this case, the weight of the product per board must be known. Errors associated with the conversion of activity data to emission factor units can be avoided by clearly specifying the required units throughout a calculation (EPA, 1993a; EPA, 1991d).

4.3.3 ROLE OF CAPTURE AND CONTROL DEVICE EFFICIENCIES IN EMISSION FACTOR ESTIMATES

Control effectiveness is the third element of the emission factor approach. Control effectiveness is a product of the capture device efficiency (including the duct system between the capture device and the control device) and the control device efficiency. The capture device efficiency indicates the percentage of the emission stream that is taken into the control system, and the control device efficiency indicates the percentage of the air pollutant that is removed from the emission stream before release to the atmosphere (EPA, 1993a; EPA, 1991d).

Control device efficiency may be determined for specific equipment by source tests measuring pollutant concentrations before and after application of the control device. However, because of possible variation in control device operation, control device malfunction, and deterioration over time, etc., the measurement is subject to the potential limitations of all source tests. Capture device efficiency can be quantified by more complex methods. Often, capture device efficiency is estimated on the basis of tests performed on similar equipment at other facilities, rather than by tests performed at the facility for which emissions are being estimated.

When test data are not available for a specific control device, a second approach using literature values to estimate control efficiency is often employed. *AP-42* includes efficiencies for control devices which are commonly encountered in industrial applications (EPA, 1995a). However, these control efficiency estimates may not be precisely applicable to specific control devices. In addition, a control device may be improperly sized for effective control of the process under consideration. Therefore, knowledge of the process and engineering judgement should be used along with the literature value.

A third method of obtaining a control device efficiency is to employ the manufacturer's design specification or guaranteed performance specification subject to field verification. However, the design efficiency reported by manufacturers is the efficiency obtainable under optimum conditions

and may not represent actual conditions. Some assessment of design efficiency may be required to adjust for source-specific conditions.

It may also be necessary to modify the control device efficiency estimate based on considerations such as downtime or gradually deteriorating conditions (e.g., degradation of fabric filter bags). If the devices are shut down periodically for maintenance or by upset conditions, the emissions released in a given hour may far exceed those released in the controlled mode over many hours of operation. Failure to account for excess emissions resulting from downtime and deteriorated efficiency can be a large source of error in the emission estimate. Although regulations and permitting conditions often exempt emissions occurring when control equipment is inoperative or malfunctioning, these emissions should be quantified and reported for emission inventory purposes.

4.3.4 PROCESS-SPECIFIC EMPIRICAL RELATIONSHIPS

In addition to the emission factors described above, *AP-42* also provides empirically developed process equations for estimating emissions from certain sources (EPA, 1995a). These equations, like emission factors, are based on throughput and control efficiency. However, they are often more complex than the simple ratio used for emission factors. Typically, these equations include such variables as air temperature, vapor pressure, and others. For example, VOC emissions from some sources, including storage tanks, vary as a function of tank size, tank color, temperature, barometric pressure, throughput, and properties of the material stored.

4.4 EMISSION MODELS

Emission models may be used to estimate emissions in cases where the calculational approach is burdensome, or in cases where a combination of parameters have been identified which affect emissions but, individually, do not provide a direct correlation. For example, the TANKS program incorporates variables such as tank color, temperature, and windspeed to obtain an emissions estimate.

Emission models may be based on measured or empirical values. The computer model may be based on theoretical equations that have been calibrated using actual data, or they may be purely empirical, in which case the equations are usually based on statistical correlations with independent variables.

Appendix F provides information on some of the more commonly used emission estimation models.

4.5 BEST APPROXIMATION OR ENGINEERING JUDGEMENT

A best approximation or engineering judgement is a final option for estimating emissions, although it is considered the least desirable method. A best approximation or engineering judgement is an emission estimate based on available information and assumptions.

If emissions must be estimated by best approximation, a few guidelines may be used to reduce the potential error. Published emission factors may be used to place order-of-magnitude boundaries on possible emissions from the process in question.

4.6 OTHER CONSIDERATIONS

4.6.1 RULE EFFECTIVENESS

Inventories performed before 1987 assumed that regulatory programs would be implemented with full effectiveness, achieving all required or intended emissions reductions and maintaining the reduction level over time. However, experience has shown regulatory programs to be less than 100 percent effective for most source categories in most areas of the country.

Rule effectiveness (RE), expressed as a fraction or percent, is an adjustment which reflects the ability of a regulatory program to achieve the required emissions reductions. The intent behind the RE factor is to account for the fact that most emission control equipment does not achieve emission reductions at the designed rates at all times and under all conditions, and that some intentional noncompliance exists. Process upsets, control equipment malfunctions, operator errors, equipment maintenance, and other nonroutine operations are typical examples of times when control device performance is expected to be less than optimal.

Rule effectiveness is especially important for VOC and CO control programs because of the small size, large number, and relative complexity of most regulated sources. It is necessary to apply rule effectiveness when preparing emissions inventories because the effectiveness of existing regulations is directly related to emissions levels. Rule effectiveness must also be considered in planning for the expected effect of further regulations. Rule effectiveness should be applied for all applicable regulations: federal, state, and local.

A default fraction of 0.80 (equal to 80 percent effectiveness) has been established by the EPA to estimate rule effectiveness in the base year inventories. This fraction is a representative estimate of the average effectiveness values, based on a survey of selected state and local personnel on the perceived effectiveness of their regulatory programs for a wide range of source categories. The 80 percent default value or local category-specific rule effectiveness factor is applied if the emissions data were determined using emission factors, results of emissions tests, or estimated control efficiencies, even if the data were obtained from a survey of the source.

Although the 80-percent rule effectiveness value may generally be valid, it can vary significantly among source categories and can have a dramatic impact on sources assumed to be controlled at a

high efficiency (e.g., 99.9 percent). Use of the default rule effectiveness factor should be carefully reviewed under these circumstances. A rule effectiveness of 100 percent may be applicable in some cases, but sources should be sure that no equipment downtime or emergency releases have occurred during the inventory period.

For the purpose of base year inventories under the CAA, the EPA allows the use of the 80-percent default value, but also gives agencies the option to derive local category-specific rule effectiveness factors through the use of a survey. Also, if rule effectiveness can be determined for a source category in a particular region using the protocol defined by the EPA's Office of Enforcement and Compliance Assurance, this rule effectiveness can be used. If a particular facility disagrees with the rule effectiveness factor used in an inventory, a case-by-case assessment of emissions can be performed to determine whether there is adequate data for emissions to be directly determined. If a facility can provide the explicit source data required by EPA, such as continuous source monitoring and control equipment functioning records for the inventory period, then emissions can be determined directly.

Where controls are not used, there is no need to apply rule effectiveness. The rule effectiveness factor should be applied to the estimated control efficiency in the calculation of emissions from a source. However, if emissions are estimated properly, there is no need to apply rule effectiveness. An example of the application is given below.

- Example:

Uncontrolled emissions	=	50 pounds (lb) per day
Estimated control equipment efficiency	=	0.90 (90 percent)
Rule effectiveness factor	=	0.80 (80 percent)
Emissions after control	=	$50[1-(0.90)(0.80)]$
	=	$50(1-0.72)$
	=	14 lb per day

Note: The EIIP Point Sources Committee is currently evaluating the application of the rule effectiveness policy. The committee will present their findings in an issues paper to the EIIP Steering Committee upon completion of their study.

4.6.2 CONTROL DEVICES

A basic description of the techniques typically used by industry to control PM₁₀, VOCs, SO₂, NO_x, and HAPs can be found in the *Handbook: Control Technologies for Hazardous Air Pollutants* (EPA, 1991d). The handbook briefly describes the efficiencies commonly achieved by major types of control devices in current use and describes how to estimate emission reductions using control systems. Table 1.4-1 lists several control devices commonly used for emission reduction

at stationary point sources. For each control device listed, the table identifies the pollutants controlled by the device and presents expected efficiency ranges.

In order to determine removal efficiencies of HAPs from the air stream, it is necessary to know the nature of the HAPs involved, including such parameters as particle size, volatility, or combustibility. Control techniques guidelines (CTG) documents have been written for numerous VOC-emitting source categories; some of these documents contain information relevant to the control of HAPs. A list of several CTGs is presented in Table 1.4-2. Information on available CTG documents can also be obtained via the Control Technology Center (CTC) assistance line (see Appendix C). Another source of information on control devices for a particular source is a series of documents collectively referred to as alternative control techniques (ACT) documents. These documents provide background information on controls, but do not provide reasonably available control technology (RACT) analysis information as do the CTGs. A list of available ACT documents is presented in Table 1.4-3.

TABLE 1.4-1
AIR POLLUTION CONTROL TECHNOLOGIES

Method	Pollutant Type			Efficiency (%)
	Organic Vapors	Inorganic Vapors	Particulates	
Cyclones			X	98 ^a
Fabric filter			X	80-99
Wet scrubbers	X ^b	X	X	95
Electrostatic precipitators			X	99.5-99.9
Carbon adsorption	X ^c	X		50 - 99
Fluidized-bed systems	X ^d			--
Absorption	X ^e			90 - 99
Condensation	X	X ^f		50 - 95 ^g
Thermal incineration	X			≥99
Catalytic incineration	X			95 - 99

Sources: EPA, 1991d; and Cooper, et al., 1994.

^a The greatest amount of control would be achieved for particles larger than 5 μm .

^b Depends on material, should be miscible in water.

^c Carbon adsorption or fired-bed systems.

^d Not widely used.

^e Material must be readily soluble in water or other solvents.

^f Depends on vaporization point of material.

^g Highly dependent on the emission stream characteristics.

-- No data available.

TABLE 1.4-2
CONTROL TECHNIQUES GUIDELINES DOCUMENTS
(GROUPS I, II, III)

Source Description	EPA Report Number	NTIS Report Number	Date of Publication
Surface Coating Operations	450/2-76-028	PB-260 386	1976
Coating of Cans, Coils, Paper, Fabrics, Automobiles, and Light-Duty Trucks	450/2-77-008	PB-272 445	1977
Surface Coating of Metal Furniture	450/2-77-032	PB-278-257	1977
Surface Coating of Insulation of Magnet Wire	450/2-77-033	PB-278-258	1977
Surface Coating of Large Appliances	450/2-77-034	PB-278-259	1978
Surface Coating of Miscellaneous Metal Parts and Products	450/2-78-015	PB-286-157	1978
Factory Surface Coating of Flat Wood Paneling	450/2-78-032	PB-292-490	1978
Graphic Arts - Rotogravure and Flexography	450/2-78-033	PB-292-490	1978
Bulk Gasoline Plants	450/2-77-035	PB-276-722	1977
Storage of Petroleum Liquids in Fixed Roof Tanks	450/2-77-036	PB-276-749	1977
Refinery Vacuum Producing Systems, Wastewater Separators, and Process Unit Turnarounds	450/2-77-025	PB-275-662	1977

TABLE 1.4-2**(CONTINUED)**

Source Description	EPA Report Number	NTIS Report Number	Date of Publication
Use of Cutback Asphalt	450/2-77-037	PB-278-185	1977
Tank Truck Gasoline Loading Terminals	450/2-77-026	PB-275-060	1977
Design Criteria for Stage I Vapor Control Systems-Gasoline Service Stations	--	--	1975
Control of Volatile Organic Compound Leaks from Petroleum Refinery Equipment	450/78-036	PB-286-158	1978
Petroleum Liquid Storage in External Floating Roof Tanks	450/2-78-047	PB-290-579	1978
Perchloroethylene Dry Cleaning Systems	450/2-78-050	PB-290-613	1978
Leaks from Gasoline Tank Trucks and Vapor Collection Systems	450/2-78-051	PB-290-568	1978
Volatile Organic Liquid Storage in Floating and Fixed Roof Tanks, Draft	--	--	1981
Large Petroleum Dry Cleaners	450/3-82-009	PB 83-124-875	1982
Synthetic Organic Chemical Polymer and Resin Manufacturing Equipment	450/3-83-006	PB-84-161-520	1984

TABLE 1.4-2**(CONTINUED)**

Source Description	EPA Report Number	NTIS Report Number	Date of Publication
Equipment Leaks from Natural Gas/Gasoline Processing Plants	450/2-83-007	PB-84-161-520	1983
Solvent Metal Cleaning	450/2-77-022	PB-274-557	1977
Manufacture of Synthesized Pharmaceutical Products	450/2-78-029	PB-290-580	1978
Manufacture of Pneumatic Rubber Tires	450/2-78-030	PB-290-557	1978
Control Techniques for Volatile Organic Emissions from Stationary Sources	450/2-78-022	PB-284-804	1978
Air Oxidation Processes in Synthetic Organic Chemical Manufacturing Industry	450/3-84-015	PB-85-164-275	1984
Manufacture of High-Density Polyethylene, Polypropylene, and Polystyrene Resins	450/3-83-008	PB-84-134-600	1983
Fugitive Emissions Sources of Organic Compounds - Additional Information on Emissions, Emissions Reductions, and Costs	450/3-82-010	PB-82-217-126	1982

TABLE 1.4-3**ALTERNATIVE CONTROL TECHNIQUES DOCUMENTS**

Source Description	EPA Report Number	NTIS Report Number	Date of Publication
Halogenated Solvent	450/3-89-030	PB 90-103268	1989
Reduction of Volatile Organic Compound Emissions from the Application of Traffic Markings	--	PB 89-148274	1988
Ethylene Oxide Sterilization/Fumigation Operations	450/3-89-007	PB 90-131434	1989
Reduction of Volatile Organic Compound Emissions from Automobile	450/3-88-009	PB 89-148282	
Organic Waste Process Vents	450/3-91-007	PB 91-148270	1990
Industrial Wastewater Volatile Organic Compound Emissions-Background Information for BACT/LAER Determinations	450/3-90-004	PB 90-194754	1990
Polystyrene Foam Manufacturing	450/3-90-020	PB 91-102111	1990

5

DATA COLLECTION

This section describes effective procedures for obtaining data for emissions inventories. Questionnaires, plant inspections, and agency air pollution files are some of the methods that are useful in collecting emissions data as well as source activity and control data. Selection of the appropriate method of data collection should include consideration of the desired level of detail of the inventory.

5.1 LEVEL OF DETAIL

Point sources can be inventoried at three levels of detail: (1) the plant level, which denotes a plant or facility that could contain several pollutant-emitting activities; (2) the point/stack level, where emissions to the ambient air from stacks, vents, or other points of emission are characterized; and (3) the process/segment level, representing the unit operations of specific source categories. A discussion of these three levels follows and includes the minimum information that will be needed for the inventory regardless of the method selected for collecting the data.

5.1.1 PLANT LEVEL

In a plant-level survey, each plant within the area should be identified and assigned a plant number. The plant should be further identified by geographic descriptors such as nonattainment area, state, county, city, street and/or mailing address, and UTM grid coordinates (or latitude/longitude). A plant contact should also be identified to facilitate communication and interaction with the plant. Additional information gathered regarding the facility should include annual fuel consumption, process throughput, hours of operation, number of employees, and the plant's standard industrial classification (SIC) code. The SIC codes are prepared and published by the U.S. Office of Management and Budget (OMB). A facility can have more than one SIC code denoting the secondary economic activities of the facility.

5.1.2 POINT/STACK LEVEL

In an inventory conducted at the point/stack level, each stack, vent, or other release point that meets or exceeds a specified minimum emission rate should be identified as an emission point. Information obtained at the point/stack level is used in application of mathematical models to

correlate air pollutant emissions with ambient air quality. Thus, in addition to the facility identification, location, and plant contact, release characteristics for each emission point are necessary for establishing a comprehensive inventory and performing evaluations with modeling programs. The necessary emission point parameters include location (latitude/longitude), stack height, stack diameter, emission rate, and gas exit velocity.

It is recommended that the location of point sources be reported with a resolution of ± 1 second at 30 meters. This level of resolution is consistent with existing data specifications in EPA emissions inventory databases. However, such a high degree of precision in specifying location may only be necessary in a limited number of applications

5.1.3 PROCESS/SEGMENT LEVEL

A plant may include various processes or operations. Each process can usually be identified by an SCC that is used to enter emissions data into a database management system. The information necessary to establish an inventory at this level includes facility identification; facility location; plant contact; process identification information; point level data; applicable regulations; operating rate data, including actual, maximum, and design operating rate or capacity; fuel use and properties data (e.g., ash content, sulfur content, level of trace elements, heat content, etc.); and identification of all pollution control equipment and its associated control efficiency (measured or design).

5.2 AVAILABILITY AND USEFULNESS OF EXISTING DATA

A major inventory planning consideration is whether, and to what extent, existing information can be used. Existing inventories can serve as a starting point for developing extensive data and support information, such as documentation of procedures. Information may also be drawn from other regulatory agency operations such as permitting, compliance, and source inspections and from other facility resources such as corporate reporting or compliance report submittals. For effective use of resources, an agency or facility should plan to fulfill specific emissions inventory requirements by building upon and improving the quality of regularly collected data.

5.3 DATA COLLECTION METHODS

5.3.1 QUESTIONNAIRES

The survey questionnaire is a technique commonly used by state and local agencies for gathering point source emissions inventory data. Figure 1.5-1 shows an example of point

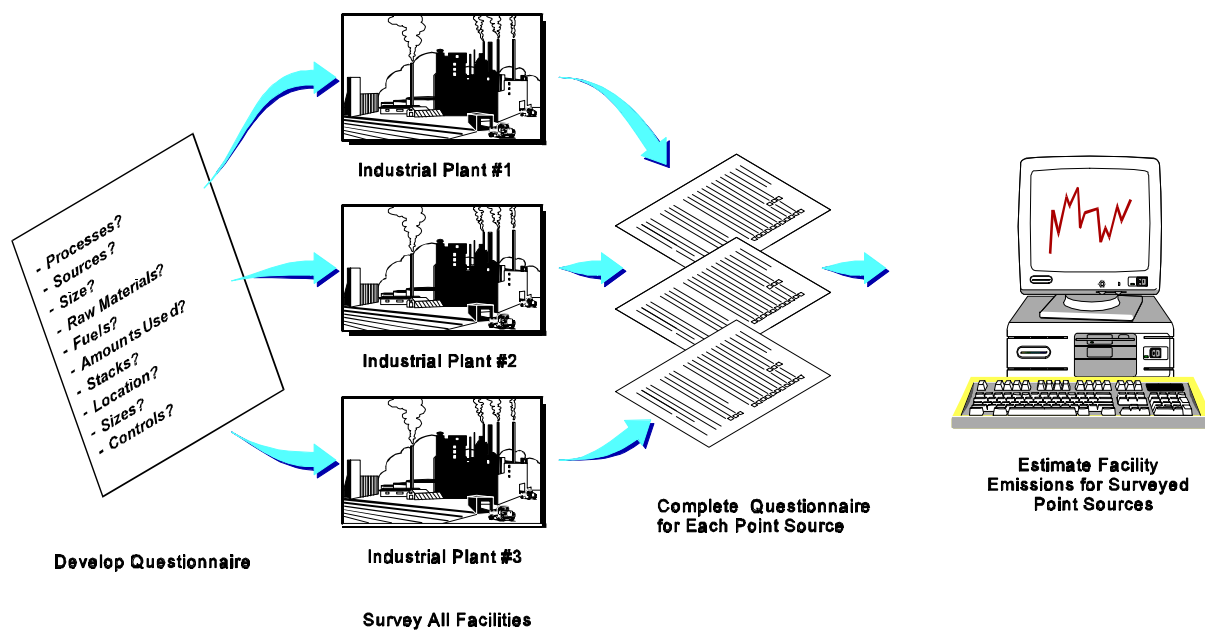


FIGURE 1.5-1. EXAMPLE OF POINT SOURCE SURVEYING

source surveying. The primary purpose of a survey is to obtain source and emissions data by means of a questionnaire that can be mailed or otherwise delivered to each facility. In order to conduct this type of data-gathering operation, the facilities to be surveyed must be identified; mailing lists must be prepared; questionnaires must be designed, assembled, and either mailed or delivered; data-handling procedures must be prepared and organized; and response-receiving systems must be established. Recently, it has become common to use computer media (floppy disks or electronic transmission) instead of paper to return questionnaire responses to the regulatory agency. This technique can also include the use of standardized computer forms or software so that data submitted to the agency is in a format easily handled by agency personnel.

The sections below provide additional detail regarding the steps involved in collecting data via questionnaires. The information is applicable regardless of whether the data is collected on paper or electronic media. See the document *Development of Questionnaires for Various Emission Inventory Uses* for more information about questionnaires (Holman and Collins, 1979).

Preparing the Mailing List

A necessary step in the mail survey is the preparation of a mailing list that tabulates the name, address, and general process category of each facility to be surveyed. The basic function of the mailing list is to identify those sources to which questionnaires will be sent. The mailing list may also serve other functions. For example, the general process category information obtained from the mailing list can assist an agency in determining those categories for which questionnaires must be designed. In addition, the size of the resulting mailing list gives an agency an indication of the numbers and types of sources that can effectively be considered in the point source inventory within resource limitations. In this regard, the mailing list can be used to help an agency determine whether the resources allocated for the compilation effort will be sufficient.

The mailing list is compiled from a variety of information sources, including:

- Existing inventories;
- Other inventories such as the Toxic Chemical Release Inventory System (TRIS);
- Air pollution control agency files;
- Other government agency files; and

- Other local information sources such as local industrial directories, yellow pages, manufacturers and suppliers, and national publications such as those listed below;
 - Dun and Bradstreet,^b Million Dollar Directory: Companies with sales over \$1,000,000 per year are compiled by SIC and county.
 - Dun and Bradstreet,^a Middle Market Directory: Companies with sales between \$50,000 and \$1,000,000 per year are compiled by SIC and county.
 - Dun and Bradstreet,^a *Industrial Directory*.
 - National Business Lists: Companies are listed by SIC and county with information on financial strength and number of employees.
 - Trade and professional society publications: Names and addresses of members are listed along with their type of business.

The mailing list should be organized to facilitate the necessary mailing and follow-up activities. A logical order in which to list companies is by city or county, then by SIC, and finally, alphabetically. Ordering the list in this manner will increase the efficiency of all subsequent data-handling tasks and will allow a quicker QC check of the list.

Limiting the Size of the Mail Survey

If more sources are identified on the mailing list than can be realistically handled with available resources, an agency should screen the mailing list in some manner to reduce the number of facilities to be sent questionnaires. This can be done in a number of ways. One way is to limit the mailout to only those sources believed to be above certain emissions levels.

The cutoff level distinction is especially important in the VOC inventory because there are so many more small sources of VOC than of most other pollutants. The cutoff level for NO_x and CO is less critical because of the usually significant contribution from the larger emitters. In general, if too high a cutoff level is chosen, many facilities will not be considered individually as point sources, and, if care is not taken, emissions from these sources may not be included in the inventory at all. Techniques are available for "scaling up" the inventory to account for missing sources; however, such procedures are invariably less accurate than point source methods. If too low a cutoff level is chosen, the result will be a significant increase in the number of plant

^a Dun and Bradstreet data can be accessed through the FACTS database on the EPA mainframe National Computing Center. Contact (919) 541-4506 to set up an account.

contacts of various sorts that must be made and the size of the point source file that must be maintained. While a low cutoff level may increase the accuracy of the inventory, the tradeoff is that many more resources are needed to compile and maintain the inventory.

Designing the Questionnaires

A questionnaire should be prepared for each source category type to be contacted. This can be done either by preparing industry-specific questionnaires for each source category or by preparing more general questionnaires that encompass many source categories. The use of general questionnaires may be advisable if the mailing list is long, if an agency is unfamiliar with many of the sources on the list, or if an agency's resources are limited. Often in practice, a general questionnaire is merely a collection of process-specific questionnaires. If sufficient resources are available, the use of industry-specific questionnaires is advantageous for certain sources.

Developing a questionnaire involves identifying and writing the appropriate questions, establishing a suitable format, and developing a cover letter and instructions for filling out the questionnaire. The basic rule is to design the questionnaire for the person who will be asked to complete it. An agency should consider that the person who will complete the questionnaire may not have the benefit of a technical background in air pollution, engineering, or physical sciences. Hence, questionnaires and instructions should be designed to be understood by persons without specialized technical training. Each question should be self-explanatory or accompanied by clear directions.

All necessary information should be solicited on the questionnaire, thus avoiding later requests for additional data. In addition to general source information such as location, ownership, and nature of business, the request should include the following:

- Process information-Because activity levels, including indicators of production and fuel consumption, are generally used with emission factors, appropriate activity levels must be obtained for each type of source. The types of activity levels needed to calculate emissions from point sources are defined for sources in *AP-42, 5th Edition*.
- Source information-Some of the emission equations in *AP-42* require information on the operation or physical characteristics of the individual point source. For example, emissions from petroleum product storage and handling operations are dependent on a number of variables, including liquid temperature, tank size, tank color, roof type, and product vapor pressure. Appropriate values for these variables should be obtained to allow an agency to use the emission equations given in *AP-42, 5th Edition*.

- Control device information-Many of the emission factors in *AP-42* represent emissions in the absence of any controls. Thus, data on control devices is helpful for determining potential emission reductions resulting from applying various control strategies, especially for those source categories for which CTG documents have been published.
- Modeling data-Application of dispersion and photochemical models requires input data characterizing the emission stream as it exits the stack or vent. These parameters include stack height, stack diameter, exit temperature, exit velocity, and geographic location in the form of latitude/longitude or UTM coordinates. [NOTE: These example parameters are appropriate for dispersion modeling but may not be representative of the types of information needed for photochemical models. Please review carefully.]

Mailing and Tracking the Questionnaires and Logging Returns

Each questionnaire sent out should be accompanied by a cover letter stating the purpose of the inventory and citing any statutes that require a response from the recipient. Cooperation in filling out and returning the questionnaire should be respectfully requested. In addition, each questionnaire should be accompanied by a set of general procedures and instructions telling the recipient how the questionnaire should be completed and the date it should be returned to the agency.

After the final mailing list has been compiled and questionnaire packages are assembled (including mailing label, cover letter, instructions, questionnaires, and self-addressed stamped envelope), an agency should proceed with the mailout activities. It is important to develop a tracking system to determine the status of each step of the mail survey. Such a tracking system should tell an agency: (1) to which companies questionnaires were mailed; (2) the dates the questionnaires were mailed; (3) the dates that each response was returned; (4) corrected name, address, and SIC information; (5) preliminary information on the type of the source; (6) whether recontacting is necessary; and (7) the status of the follow-up contact effort. Tracking can be accomplished manually through the use of worksheets or through the use of a simple computer program. A computer printout of the mailing list can be formatted for use as a tracking worksheet.

5.3.2 PLANT INSPECTIONS

During plant inspections, agency personnel usually examine the various processes at a particular facility and interview appropriate plant personnel. If an agency's resources allow, source testing may be conducted as a part of the plant inspection.

The major advantage of the plant inspection is that it should provide more thorough and accurate information about an emitter than does the questionnaire alone. Errors resulting from a company's misinterpretation of the questionnaire, or an agency's misinterpretation of the response, are also minimized. Finally, in cases where a process is unique or complex, the only realistic way for an agency to gain an adequate understanding of the emitting points and the variables affecting emissions is to observe the plant equipment personally and to review the operations and process schematics with the appropriate plant personnel.

5.3.3 ACCESSING AGENCY AIR POLLUTION FILES

An agency may have special files or databases that can be accessed for use in emissions inventory development. These files may include permit files, compliance files, or emissions statements. Permits are typically required for construction, startup, modifications, and continuing operation of an emissions source. Permit applications generally include enough information about a potential source to describe the nature of the source and to estimate the magnitude of emissions that will result from its operations. Some permits also include source test data.

Some agencies may also maintain a compliance file which records the agency's dealing with each source on enforcement matters. A compliance file might contain a list of air pollution regulations applicable to a given source, a history of contacts made with that source on enforcement matters, and an agreed-upon schedule for the source to effect some sort of control measures. Such information may be helpful in the preparation of an inventory.

5.3.4 EMISSIONS ESTIMATES CONDUCTED BY PLANT PERSONNEL

The number and complexity of processes within a given plant, in addition to the difficulty of accessing all the data necessary to complete emission calculations, can make emissions estimation a complex task, with significant opportunity for error. A few general guidelines for conducting overall emissions estimates for a plant are listed below:

- Identify and document the emission sources;
- Identify the types of pollutants and quantify the emissions;
- Compile the source and emissions data into a useable format;
- Design and implement a quality assurance plan; and
- Seek assistance from EPA, state, and local agencies.

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6

INVENTORY REPORTING AND DOCUMENTATION

Documentation is an integral part of an emissions inventory. Before submittal, internal review of the written documentation of an inventory's data sources and procedures may uncover errors in assumptions, calculations, or methods. Early correction of these errors will result in a more reliable and technically defensible database, which is essential in some critical aspects of the inventory such as source impact assessments and development of emissions control strategies.

Following submittal of the inventory, the documentation allows the quality of the inventory to be effectively judged. An emissions inventory that is documented according to standardized guidelines enables the receiving agency to review the inventory in a consistent manner. Because it is recognized that some variability is needed to meet the specific needs of each inventory region, standardization is emphasized for the types of data reported, but not the format in which they are reported. Inventories not meeting the minimum data reporting and documentation standards may be deemed unacceptable and returned to the preparer for modification before any further review of technical quality is performed.

The reporting steps of the emissions inventory development process should be anticipated during planning. Planning the level of documentation required will: (1) ensure that important supporting information is properly developed and maintained; (2) allow extraneous information to be identified and discarded, thereby reducing the paperwork burden; (3) help determine data storage requirements; and (4) aid in identifying aspects of the inventory on which to concentrate the QA efforts.

6.1 WRITTEN DOCUMENTATION

Written documentation should include summary tables and a report discussing the inventory development procedures and point source results. Large volumes of detailed data should be put into appendices but clearly linked to the text discussion in terms of how they were used to determine emissions.

For inventories prepared by a plant, emissions may be summarized by pollutant, equipment/source, and/or stack. For larger inventories prepared by a state or local agency, the presentation

may be more broadly focussed by source category and/or county. Graphics may be useful to illustrate the contribution of point sources to areawide emissions.

The report should address data collection methods and tools, how the inventoried sources were identified, the completeness of source coverage, and procedures for estimating emissions. If any source categories are excluded, they should be listed and a reason for the exclusion should be provided. If applicable, an explanation should be included on how emissions were temporally allocated and on what basis. The methodology by which activity levels and emissions were determined for each plant should also be explained.

The appendices should contain the results of all information surveys that have been conducted. All sources inventoried should be listed according to their source category type (e.g., storage tank, process vent, petroleum refinery, graphic arts, degreasing, etc.). All references and other data sources should also be included or, if they are too voluminous, they should be clearly cited in the inventory submittal and kept in a readily accessible location on site.

For a more detailed discussion of documentation requirements, consult the EPA document *Example Documentation Report for 1990 Base Year Ozone and Carbon Monoxide SIP Emissions Inventories* (EPA, 1992b).

6.2 COMPUTERIZED DATA REPORTING

Along with the written documentation of the inventory, an electronic submittal inventory is also recommended. State and local agencies may submit their data to EPA, using one of the data transfer options available. Specific information on the data transfer options may be located on the EPA's 1996 Emission Inventory World Wide Website (expected to be available mid-July 1997).

7

QUALITY ASSURANCE/ QUALITY CONTROL

The development of a reasonable and comprehensive emissions inventory requires the implementation of quality assurance/quality control (QA/QC) procedures throughout the entire inventory process. The main objective of the QA and QC for emissions inventories is the development of accurate, useful, and reliable data. These procedures should be applied consistently by the state or local agency in preparing or reviewing inventories.

Prior to establishing a quality program or plan, the meaning of quality as it relates to the inventory should be clarified. Quality control is the overall system of routine technical activities that are designed to measure and control the quality of the inventory as it is being developed. Quality assurance is an integrated system or program of activities involving planning, QC, quality assessment, reporting, and quality improvements which are designed to help ensure that the inventory meets the data quality goals or objectives established prior to developing the inventory.

7.1 QUALITY CONTROL

Quality control is the performance of standardized activities during the course of inventory preparation to ensure data quality. Quality control activities include technical reviews, accuracy checks, and the use of approved standardized procedures for emissions calculations. These internal activities are designed to provide the first level of quality checking and should be included in inventory development planning, data collection, data analysis, emissions calculation, and reporting. Quality control is best implemented through the use of standardized checklists that assess the adequacy of the data and procedures at various intervals in the inventory process. Specifically, QC checklists are used to monitor the following procedures and tasks:

- Data collection;
- Data calculation;
- Emission estimates;
- Data validity;

- Data reasonableness;
- Data completeness;
- Data coding and recording; and
- Data tracking.

The checklist can aid the preparer in finalizing the inventory prior to submittal to a reviewing agency. An example QC checklist for stationary point sources is included in Appendix D. This checklist includes questions concerning completeness (e.g., questions whether all the VOC point sources ≥ 10 tpy have been accounted for); use of approved procedures (e.g., questions as to which model was used to estimate wastewater treatment emissions); and reasonableness (e.g., questions whether all stack heights are greater than 50 feet and all stack diameters between 0.5 and 30 feet). For additional information and guidance on applying reasonableness or reality checks to an inventory, please refer to Chapter 3, Volume VI of the EIIP series.

7.2 QUALITY ASSURANCE

Quality assurance activities include helping inventory preparers identify critical phases of the inventory development process that will affect the technical soundness, accuracy, and completeness of the inventory. After identifying these phases of the process, QC procedures are developed to monitor the quality of the data and work to help ensure the generation of an accurate and complete inventory. Other QA activities include the evaluation of the effectiveness of these QC procedures by conducting data and procedural audits at critical phases of the inventory development process.

If quality concerns are found during QA audits, they should be discussed with the personnel involved so that actions can be taken immediately to resolve the issues. The quality concerns, recommendations for corrective actions, and satisfactory aspects of the QC program should be summarized in an audit report. Inventory development personnel are responsible for the resolution of the quality concerns in a timely fashion so that the work progresses as planned and the quality of the data is always being optimized.

The keys to the success of a QA/QC program are proper planning and the involvement of QA personnel to help design the QC program. An essential part of proper planning is the specification of the data quality objectives. Much of the data used for inventories are not sufficient to establish quantitative goals. Therefore, qualitative goals must be specified.

Table 1.7-1 lists six important quality goals for inventories and gives general methods for achieving those goals.

7.3 QA/QC PROCEDURES FOR SPECIFIC EMISSION ESTIMATION METHODS

7.3.1 SOURCE TESTS AND CONTINUOUS EMISSIONS MONITORING (CEM)

The main objective of any QA/QC effort for any program is to independently assess and document the precision, accuracy, and adequacy of data. In an emissions inventory developed from source tests and CEM, the data of interest will be that generated during sampling and analysis. As a first step, a QA Plan should be developed by the team conducting the test prior to each specific field test. Next, it is essential to the production of valid test data that the emissions measurement program be performed by qualified personnel using appropriate and properly functioning test equipment. Sampling equipment, such as flow meters and gauges, must be properly calibrated and maintained. Emphasis is placed upon these standard practices as means of ensuring the validity of results. Deviations from standard procedures must be kept to a minimum and applied only when absolutely necessary to obtain representative samples. For compliance testing, deviations from standard procedures may be used only with approval of the regulatory agency. Any changes in methodology must be based on sound engineering judgement and must be thoroughly documented.

Thorough descriptions of stack sampling procedures, source sampling tools and equipment, identification and handling of samples, laboratory analysis, use of the sampling data, and preparation of reports are available in several references, such as the *Quality Assurance Handbook for Air Pollution Measurement Systems: Volume III. Stationary Source Specific Methods* (EPA, 1984). This document also contains a detailed discussion of interpretations of CEM data, required accuracy calculations, specific criteria for unacceptable CEM data, and indications that a CEM is out of control.

A systems audit should be conducted on-site as a qualitative review of the various aspects of a total sampling and/or analytical system to assess its overall effectiveness. The systems audit should represent an objective evaluation of each system with respect to strengths, weaknesses, and potential problem areas. The audit provides an evaluation of the adequacy of the overall measurement system(s) to provide data of known quality which are sufficient, in terms of quantity and quality, to meet the program objectives.

Quality control procedures for all instruments used to continuously collect emissions data are identical. The primary control check for precision of the continuous monitors is daily analysis of control standards.

TABLE 1.7-1

METHODS FOR ACHIEVING EMISSION INVENTORY DATA QUALITY OBJECTIVES

Data Quality Objectives	Methods
Ensure correct implementation of EPA guidance.	<ul style="list-style-type: none"> • Review inventory documentation, comparing actual procedures used to those required.
Where EPA guidance was not used or unavailable, assess bias by evaluating the reasonableness of the approach used.	<ul style="list-style-type: none"> • Technical review of approach used. • Compare with results from other methods.
Ensure accuracy of input data.	<ul style="list-style-type: none"> • Check accuracy of transcription of data. • Check any conversion factors used. • Assess validity of assumptions used to calculate input data. • Verify that the data source was current and the best available.
Ensure accuracy of calculations.	<ul style="list-style-type: none"> • Reconstruct a representative sample (or all) by hand.
Assess comparability and representativeness of inventory.	<ul style="list-style-type: none"> • Compare emissions to those from similar inventories. • Cross-check activity data by comparing it to surrogates.
Assess completeness of inventory.	<ul style="list-style-type: none"> • Compare list of source categories or emission points to those listed in EPA guidance. • Cross-check against other published inventories, business directories, etc.

The emission rates of a particular pollutant are a function of a number of stack gas parameters such as concentration and flow rate which are measured during testing. Sensitivity and error analyses illustrate the extent to which the emission estimate may be affected by variability in the measured values. See Volume VI of the EIIP series of guidance documents for additional information on evaluating how the quality of the calculated emission rates are affected by the accuracy of the measurements.

7.3.2 MATERIAL BALANCES

The accuracy and reliability of emission values calculated using the material balance approach are related to the quality of material usage and speciation data, and knowledge of the different fate pathways for the material.

The quantity of material used in an operation is often "eye-balled," a procedure that can easily result in an error of as great as 25 percent. This level of uncertainty can be reduced by using a standardized method of measuring quantities such as a gravimetric procedure (e.g., weighing a container before and after using the material) or use of a stick or gauge to measure the level of liquid in a container. For certain applications (e.g., those where very small quantities of materials are used), it may be more accurate to make these types of measurements monthly or annually, rather than after each application event. Another technique for determining usage quantities would be to use purchase and inventory records.

Uncertainty of emissions using the material balance approach is also related to the quality of material speciation data, which is typically extracted from Material Safety Data Sheets (MSDSs). If speciation data are not available on the MSDS, the material manufacturer should be contacted. Finally, a thorough knowledge of the amount of a material exiting a process through each fate pathway is needed. Typical fate pathways include product, recycle/reuse, solid waste, liquid waste, and air emissions.

7.3.3 EMISSION FACTORS

Realizing that site specific test or CEM data are not always available or the most cost effective means for estimating air emissions from a facility, emission factors are often used as an alternative method for calculating emissions. Data used to develop emission factors available in *AP-42* or the FIRE system, for example, are obtained from source tests, material balance studies, and engineering estimates. *AP-42* and FIRE identify any qualifications or limitations of the data. *AP-42* and FIRE emission factors represent the best available information on average emissions from the identified source categories as of the date of factor publication.

Each emission factor published in *AP-42* or FIRE receives a quality rating, which serves as an assessment of the confidence the generator of that value places in the quality of the emission factor. When using existing emission factors, the user should be familiar with the criteria for

assigning both data quality ratings and emission factor ratings as described in the document *Technical Procedures for Developing AP-42 Emission Factors and Preparing AP-42 Sections* (EPA, 1993b).

The data quality ratings for source tests are as follows:

- A-Rated Test - Excellent - The test(s) was performed by a sound methodology and reported in enough detail for adequate validation. These tests are not necessarily EPA reference test methods, although such reference methods are certainly to be used as a guide.
- B-Rated Test - Above Average - The test(s) was performed by a generally sound methodology but lacked enough detail for adequate validation.
- C-Rated Test - Average - The test(s) was based on a nonvalidated or draft methodology or lacked a significant amount of background data.
- D-Rated Test - Below Average - Test(s) was based on a generally unacceptable method but may provide an order-of-magnitude value for the source.

Once the data quality ratings for the source tests are assigned, these ratings along with the number of source tests available for a given emission point are evaluated. Because of the almost impossible task of assigning a meaningful confidence limit to industry-specific variables (e.g., sample size versus sample population, industry and facility variability, method of measurement), the use of a statistical confidence interval for establishing a representative emission factor for each source category is usually not practical. Therefore, some subjective quality rating is necessary. The following factor quality ratings are used for the emission factors found in AP-42, FIRE, or any EPA published document:

- A - Excellent - The emission factor was developed only from A-rated test data taken from many randomly chosen facilities in the industry population. The source category is specific enough to minimize variability within the source category population.
- B - Above Average - The emission factor was developed only from A-rated test data from a reasonable number of facilities. Although no specific bias is evident, it is not clear if the facilities tested represent a random sample of the industry. As with the A-rating, the source category is specific enough to minimize variability within the source category population.
- C - Average - The emission factor was developed only from A- and B-rated test data from a reasonable number of facilities. Although no specific bias is evident, it

is not clear if the facilities tested represent a random sample of the industry. As with the A-rating, the source category is specific enough to minimize variability within the source category population.

- D - Below Average - The emission factor was developed only from A- and B-rated test data from a small number of facilities, and there may be reason to suspect that these facilities do not represent a random sample of the industry. There also may be evidence of variability within the source category population.
- E - Poor - The emission factor was developed from C- and D-rated test data, and there may be reason to suspect that the facilities tested do not represent a random sample of the industry. There also may be evidence of variability within the source category population.
- U - Unrated or Unratable - The emission factor was developed from suspect data with no supporting documentation to accurately apply an "A" through "E" rating. A "U" rating may be applied in the following circumstances (FIRE):

U1 - Mass Balance (for example, estimating air emissions based on raw material input, product recovery efficiency, and percent control).

U2 - Source test deficiencies (such as inadequate quality assurance/quality control, questionable source test methods, only one source test).

U3 - Technology transfer.

U4 - Engineering judgement.

U5 - Lack of supporting documentation.

7.3.4 MODELING

When a model or other software program is used to calculate emissions, manual verification (by hand) of each type of calculation should be performed. If the calculations are complex and can not be easily reconstructed, an alternative approach is to try to duplicate the results using another calculation method. The input data should also be verified for accuracy. For additional guidance on QA/QC procedures for using models, refer to Chapter 3, *General QA/QC Methods* (EIIP, 1996).

7.4 DATA ATTRIBUTE RATING SYSTEM (DARS)

The EPA has developed a Data Attribute Rating System (DARS) to assist in evaluating data associated with emission inventories (Beck, et al., 1994). The system disaggregates emission inventories into emission factors and activity data, then assigns a numerical score to each of these two components. Each score is based on what is known about the factor and activity parameters, such as the specificity to the source category and the measurement or estimation techniques employed. The resulting emission factor and activity data scores are combined to arrive at an overall confidence rating for the inventory.

The DARS defines certain classifying attributes that are believed to influence the accuracy, appropriateness, and reliability of an emission factor or activity and derived emission estimates. This approach is semiquantitative in that it uses numeric scores; however, scoring is based on qualitative and often subjective assessments. The proposed approach, when applied systematically by inventory analysts, can be used to provide a measure of the merits of one emission estimate relative to another.

The DARS provides the means for determining the comparability and transparency of rated inventories. The inventory with the higher overall rating is likely to be a better estimate given the techniques and methodologies employed in its development. Several methods of combining the values are discussed and compared in the paper entitled *A Data Attribute Rating System* (Beck, et al., 1994).

The DARS is currently being developed into a PC-based system which will enable users to import emissions inventories for scoring.

8

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APPENDIX A

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FROM *AP-42*, 5TH EDITION

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APPENDIX B

CONVERSION FACTORS

FROM *AP-42*, 5TH EDITION,

APPENDIX A

Source: EPA. January 1995. *Compilation of Air Pollutant Emission Factors, Volume I: Stationary Point and Area Sources, Fifth Edition and Supplements A-B*, AP-42. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. Research Triangle Park, North Carolina.

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APPENDIX A

MISCELLANEOUS DATA AND CONVERSION FACTORS

SOME USEFUL WEIGHTS AND MEASURES

Unit Of Measure	Equivalent	
grain	0.002	ounces
gram	0.04	ounces
ounce	28.35	grams
kilogram	2.21	pounds
pound	0.45	kilograms
pound (troy)	12	ounces
ton (short)	2000	pounds
ton (long)	2240	pounds
ton (metric)	2200	pounds
ton (shipping)	40	feet ³
centimeter	0.39	inches
inch	2.54	centimeters
foot	30.48	centimeters
meter	1.09	yards
yard	0.91	meters
mile	1.61	kilometers
centimeter ²	0.16	inches ²
inch ²	6.45	centimeters ²
foot ²	0.09	meters ²
meter ²	1.2	yards ²
yard ²	0.84	meters ²
mile ²	2.59	kilometers ²
centimeter ³	0.061	inches ³
inch ³	16.39	centimeters ³
foot ³	283.17	centimeters ³
foot ³	1728	inches ³

SOME USEFUL WEIGHTS AND MEASURES (cont.)

Unit Of Measure	Equivalent	
meter ³	1.31	yards ³
yard ³	0.77	meters ³
cord	128	feet ³
cord	4	meters ³
peck	8	quarts
bushel (dry)	4	pecks
bushel	2150.4	inches ³
gallon (U. S.)	231	inches ³
barrel	31.5	gallons
hogshead	2	barrels
township	36	miles ²
hectare	2.5	acres

MISCELLANEOUS DATA

One cubic foot of anthracite coal weighs about 53 pounds.

One cubic foot of bituminous coal weighs from 47 to 50 pounds.

One ton of coal is equivalent to two cords of wood for steam purposes.

A gallon of water (U. S. Standard) weighs 8.33 pounds and contains 231 cubic inches.

There are 9 square feet of heating surface to each square foot of grate surface.

A cubic foot of water contains 7.5 gallons and 1728 cubic inches, and weighs 62.5 lbs.

Each nominal horsepower of a boiler requires 30 to 35 pounds of water per hour.

A horsepower is equivalent to raising 33,000 pounds one foot per minute, or 550 pounds one foot per second.

To find the pressure in pounds per square inch of a column of water, multiply the height of the column in feet by 0.434.

TYPICAL PARAMETERS OF VARIOUS FUELS^a

Type Of Fuel	Heating Value		Sulfur % (by weight)	Ash % (by weight)
	kcal	Btu		
Solid Fuels				
Bituminous Coal	7,200/kg	13,000/lb	0.6-5.4	4-20
Anthracite Coal	6,810/kg	12,300/lb	0.5-1.0	7.0-16.0
Lignite (@ 35% moisture)	3,990/kg	7,200/lb	0.7	6.2
Wood (@ 40% moisture)	2,880/kg	5,200/lb	N	1-3
Bagasse (@ 50% moisture)	2,220/kg	4,000/lb	N	1-2
Bark (@ 50% moisture)	2,492/kg	4,500/lb	N	1-3 ^b
Coke, Byproduct	7,380/kg	13,300/lb	0.5-1.0	0.5-5.0
Liquid Fuels				
Residual Oil	9.98 x 10 ⁶ /m ³	150,000/gal	0.5-4.0	0.05-0.1
Distillate Oil	9.30 x 10 ⁶ /m ³	140,000/gal	0.2-1.0	N
Diesel	9.12 x 10 ⁶ /m ³	137,000/gal	0.4	N
Gasoline	8.62 x 10 ⁶ /m ³	130,000/gal	0.03-0.04	N
Kerosene	8.32 x 10 ⁶ /m ³	135,000/gal	0.02-0.05	N
Liquid Petroleum Gas	6.25 x 10 ⁶ /m ³	94,000/gal	N	N
Gaseous Fuels				
Natural Gas	9,341/m ³	1,050/SCF	N	N
Coke Oven Gas	5,249/m ³	590/SCF	0.5-2.0	N
Blast Furnace Gas	890/m ³	100/SCF	N	N

^a N = negligible.

^b Ash content may be considerably higher when sand, dirt, etc., are present.

THERMAL EQUIVALENTS FOR VARIOUS FUELS

Type Of Fuel	kcal	Btu (gross)
Solid fuels		
Bituminous coal	$(5.8 \text{ to } 7.8) \times 10^6/\text{Mg}$	$(21.0 \text{ to } 28.0) \times 10^6/\text{ton}$
Anthracite coal	$7.03 \times 10^6/\text{Mg}$	$25.3 \times 10^6/\text{ton}$
Lignite	$4.45 \times 10^6/\text{Mg}$	$16.0 \times 10^6/\text{ton}$
Wood	$1.47 \times 10^6/\text{m}^3$	$21.0 \times 10^6/\text{cord}$
Liquid fuels		
Residual fuel oil	$10 \times 10^3/\text{liter}$	$6.3 \times 10^6/\text{bbl}$
Distillate fuel oil	$9.35 \times 10^3/\text{liter}$	$5.9 \times 10^6/\text{bbl}$
Gaseous fuels		
Natural gas	$9,350/\text{m}^3$	$1,050/\text{ft}^3$
Liquefied petroleum gas		
Butane	$6,480/\text{liter}$	$97,400/\text{gal}$
Propane	$6,030/\text{liter}$	$90,500/\text{gal}$

WEIGHTS OF SELECTED SUBSTANCES

Type Of Substance	g/liter	lb/gal
Asphalt	1030	8.57
Butane, liquid at 60°F	579	4.84
Crude oil	850	7.08
Distillate oil	845	7.05
Gasoline	739	6.17
Propane, liquid at 60°F	507	4.24
Residual oil	944	7.88
Water	1000	8.4

DENSITIES OF SELECTED SUBSTANCES

Substance	Density	
Fuels		
Crude Oil	874 kg/m ³	7.3 lb/gal
Residual Oil	944 kg/m ³	7.88 lb/gal
Distillate Oil	845 kg/m ³	7.05 lb/gal
Gasoline	739 kg/m ³	6.17 lb/gal
Natural Gas	673 kg/m ³	1 lb/23.8 ft ³
Butane	579 kg/m ³	4.84 lb/gal (liquid)
Propane	507 kg/m ³	4.24 lb/gal (liquid)
Wood (Air dried)		
Elm	561 kg/m ³	35 lb/ft ³
Fir, Douglas	513 kg/m ³	32 lb/ft ³
Fir, Balsam	400 kg/m ³	25 lb/ft ³
Hemlock	465 kg/m ³	29 lb/ft ³
Hickory	769 kg/m ³	48 lb/ft ³
Maple, Sugar	689 kg/m ³	43 lb/ft ³
Maple, White	529 kg/m ³	33 lb/ft ³
Oak, Red	673 kg/m ³	42 lb/ft ³
Oak, White	769 kg/m ³	48 lb/ft ³
Pine, Southern	641 kg/m ³	40 lb/ft ³
Agricultural Products		
Corn	25.4 kg/bu	56 lb/bu
Milo	25.4 kg/bu	56 lb/bu
Oats	14.5 kg/bu	32 lb/bu
Barley	21.8 kg/bu	48 lb/bu
Wheat	27.2 kg/bu	60 lb/bu
Cotton	226 kg/bale	500 lb/bale
Mineral Products		
Brick	2.95 kg/brick	6.5 lb/brick
Cement	170 kg/bbl	375 lb/bbl
Cement	1483 kg/m ³	2500 lb/yd ³

DENSITIES OF SELECTED SUBSTANCES (cont.).

Substance	Density	
Concrete	2373 kg/m ³	4000 lb/yd ³
Glass, Common	2595 kg/m ³	162 lb/ft ³
Gravel, Dry Packed	1600 - 1920 kg/m ³	100 - 120 lb/ft ³
Gravel, Wet	2020 kg/m ³	126 lb/ft ³
Gypsum, Calcined	880 - 960 kg/m ³	55 - 60 lb/ft ³
Lime, Pebble	850 - 1025 kg/m ³	53 - 64 lb/ft ³
Sand, Gravel (Dry, loose)	1440 - 1680 kg/m ³	90 - 105 lb/ft ³

CONVERSION FACTORS

The table of conversion factors on the following pages contains factors for converting English to metric units and metric to English units as well as factors to manipulate units within the same system. The factors are arranged alphabetically by unit within the following property groups.

- Area
- Density
- Energy
- Force
- Length
- Mass
- Pressure
- Velocity
- Volume
- Volumetric Rate

To convert a number from one unit to another:

1. Locate the unit in which the number is currently expressed in the left-hand column of the table;
2. Find the desired unit in the center column; and
3. Multiply the number by the corresponding conversion factor in the right-hand column.

CONVERSION FACTORS^a

To Convert From	To	Multiply By
Area		
Acres	Sq feet	4.356×10^4
Acres	Sq kilometers	4.0469×10^{-3}
Acres	Sq meters	4.0469×10^3
Acres	Sq miles (statute)	1.5625×10^{-3}
Acres	Sq yards	4.84×10^3
Sq feet	Acres	2.2957×10^{-5}
Sq feet	Sq cm	929.03
Sq feet	Sq inches	144.0
Sq feet	Sq meters	0.092903
Sq feet	Sq miles	3.587×10^{-8}
Sq feet	Sq yards	0.111111
Sq inches	Sq feet	6.9444×10^{-3}
Sq inches	Sq meters	6.4516×10^{-4}
Sq inches	Sq mm	645.16
Sq kilometers	Acres	247.1
Sq kilometers	Sq feet	1.0764×10^7
Sq kilometers	Sq meters	1.0×10^6
Sq kilometers	Sq miles	0.386102
Sq kilometers	Sq yards	1.196×10^6
Sq meters	Sq cm	1.0×10^4
Sq meters	Sq feet	10.764
Sq meters	Sq inches	1.55×10^3
Sq meters	Sq kilometers	1.0×10^{-6}
Sq meters	Sq miles	3.861×10^{-7}
Sq meters	Sq mm	1.0×10^6
Sq meters	Sq yards	1.196
Sq miles	Acres	640.0
Sq miles	Sq feet	2.7878×10^7
Sq miles	Sq kilometers	2.590

CONVERSION FACTORS (cont.).

To Convert From	To	Multiply By
Sq miles	Sq meters	2.59×10^6
Sq miles	Sq yards	3.0976×10^6
Sq yards	Acres	2.0661×10^{-4}
Sq yards	Sq cm	8.3613×10^3
Sq yards	Sq ft	9.0
Sq yards	Sq inches	1.296×10^3
Sq yards	Sq meters	0.83613
Sq yards	Sq miles	3.2283×10^{-7}
Density		
Dynes/cu cm	Grams/cu cm	1.0197×10^{-3}
Grains/cu foot	Grams/cu meter	2.28835
Grams/cu cm	Dynes/cu cm	980.665
Grams/cu cm	Grains/milliliter	15.433
Grams/cu cm	Grams/milliliter	1.0
Grams/cu cm	Pounds/cu inch	1.162
Grams/cu cm	Pounds/cu foot	62.428
Grams/cu cm	Pounds/cu inch	0.036127
Grams/cu cm	Pounds/gal (Brit.)	10.022
Grams/cu cm	Pounds/gal (U. S., dry)	9.7111
Grams/cu cm	Pounds/gal (U. S., liq.)	8.3454
Grams/cu meter	Grains/cu foot	0.4370
Grams/liter	Pounds/gal (U. S.)	8.345×10^{-3}
Kilograms/cu meter	Grams/cu cm	0.001
Kilograms/cu meter	Pounds/cu ft	0.0624
Kilograms/cu meter	Pounds/cu in	3.613×10^{-5}
Pounds/cu foot	Grams/cu cm	0.016018
Pounds/cu foot	kg/cu meter	16.018
Pounds/cu inch	Grams/cu cm	27.68
Pounds/cu inch	Grams/liter	27.681
Pounds/cu inch	kg/cu meter	2.768×10^4

CONVERSION FACTORS (cont.).

To Convert From	To	Multiply By
Pounds/gal (U. S., liq.)	Grams/cu cm	0.1198
Pounds/gal (U. S., liq.)	Pounds/cu ft	7.4805
Energy		
Btu	Cal. gm (IST.)	251.83
Btu	Ergs	1.05435×10^{10}
Btu	Foot-pounds	777.65
Btu	Hp-hours	3.9275×10^{-4}
Btu	Joules (Int.)	1054.2
Btu	kg-meters	107.51
Btu	kW-hours (Int.)	2.9283×10^{-4}
Btu/hr	Cal. kg/hr	0.252
Btu/hr	Ergs/sec	2.929×10^6
Btu/hr	Foot-pounds/hr	777.65
Btu/hr	Horsepower (mechanical)	3.9275×10^{-4}
Btu/hr	Horsepower (boiler)	2.9856×10^{-5}
Btu/hr	Horsepower (electric)	3.926×10^{-4}
Btu/hr	Horsepower (metric)	3.982×10^{-4}
Btu/hr	Kilowatts	2.929×10^{-4}
Btu/lb	Foot-pounds/lb	777.65
Btu/lb	Hp-hr/lb	3.9275×10^{-4}
Btu/lb	Joules/gram	2.3244
Calories, kg (mean)	Btu (IST.)	3.9714
Calories, kg (mean)	Ergs	4.190×10^{10}
Calories, kg (mean)	Foot-pounds	3.0904×10^3
Calories, kg (mean)	Hp-hours	1.561×10^{-3}
Calories, kg (mean)	Joules	4.190×10^3
Calories, kg (mean)	kg-meters	427.26
Calories, kg (mean)	kW-hours (Int.)	1.1637×10^{-3}
Ergs	Btu	9.4845×10^{-11}
Ergs	Foot-poundals	2.373×10^{-6}

CONVERSION FACTORS (cont.).

To Convert From	To	Multiply By
Ergs	Foot-pounds	7.3756×10^{-8}
Ergs	Joules (Int.)	9.99835×10^{-8}
Ergs	kW-hours	2.7778×10^{-14}
Ergs	kg-meters	1.0197×10^{-8}
Foot-pounds	Btu (IST.)	1.2851×10^{-3}
Foot-pounds	Cal. kg (IST.)	3.2384×10^{-4}
Foot-pounds	Ergs	1.3558×10^7
Foot-pounds	Foot-poundals	32.174
Foot-pounds	Hp-hours	5.0505×10^{-7}
Foot-pounds	Joules	1.3558
Foot-pounds	kg-meters	0.138255
Foot-pounds	kW-hours (Int.)	3.76554×10^{-7}
Foot-pounds	Newton-meters	1.3558
Foot-pounds/hr	Btu/min	2.1432×10^{-5}
Foot-pounds/hr	Ergs/min	2.2597×10^5
Foot-pounds/hr	Horsepower (mechanical)	5.0505×10^{-7}
Foot-pounds/hr	Horsepower (metric)	5.121×10^{-7}
Foot-pounds/hr	Kilowatts	3.766×10^{-7}
Horsepower (mechanical)	Btu (mean)/hr	2.5425×10^3
Horsepower (mechanical)	Ergs/sec	7.457×10^9
Horsepower (mechanical)	Foot-pounds/hr	1.980×10^6
Horsepower (mechanical)	Horsepower (boiler)	0.07602
Horsepower (mechanical)	Horsepower (electric)	0.9996
Horsepower (mechanical)	Horsepower (metric)	1.0139
Horsepower (mechanical)	Joules/sec	745.70
Horsepower (mechanical)	Kilowatts (Int.)	0.74558
Horsepower (boiler)	Btu (mean)/hr	3.3446×10^4
Horsepower (boiler)	Ergs/sec	9.8095×10^{10}
Horsepower (boiler)	Foot-pounds/min	4.341×10^5
Horsepower (boiler)	Horsepower (mechanical)	13.155

CONVERSION FACTORS (cont.).

To Convert From	To	Multiply By
Horsepower (boiler)	Horsepower (electric)	13.15
Horsepower (boiler)	Horsepower (metric)	13.337
Horsepower (boiler)	Joules/sec	9.8095×10^3
Horsepower (boiler)	Kilowatts	9.8095
Horsepower (electric)	Btu (mean)/hr	2.5435×10^3
Horsepower (electric)	Cal. kg/hr	641.87
Horsepower (electric)	Ergs/sec	7.46×10^9
Horsepower (electric)	Foot-pounds/min	3.3013×10^4
Horsepower (electric)	Horsepower (boiler)	0.07605
Horsepower (electric)	Horsepower (metric)	1.0143
Horsepower (electric)	Joules/sec	746.0
Horsepower (electric)	Kilowatts	0.746
Horsepower (metric)	Btu (mean)/hr	2.5077×10^3
Horsepower (metric)	Ergs/sec	7.355×10^9
Horsepower (metric)	Foot-pounds/min	3.255×10^4
Horsepower (metric)	Horsepower (mechanical)	0.98632
Horsepower (metric)	Horsepower (boiler)	0.07498
Horsepower (metric)	Horsepower (electric)	0.9859
Horsepower (metric)	kg-meters/sec	75.0
Horsepower (metric)	Kilowatts	0.7355
Horsepower-hours	Btu (mean)	2.5425×10^3
Horsepower-hours	Foot-pounds	1.98×10^6
Horsepower-hours	Joules	2.6845×10^6
Horsepower-hours	kg-meters	2.73745×10^5
Horsepower-hours	kW-hours	0.7457
Joules (Int.)	Btu (IST.)	9.4799×10^{-4}
Joules (Int.)	Ergs	1.0002×10^7
Joules (Int.)	Foot-poundals	12.734
Joules (Int.)	Foot-pounds	0.73768
Joules (Int.)	kW-hours	2.778×10^{-7}

CONVERSION FACTORS (cont.).

To Convert From	To	Multiply By
Joules (Int.)/sec	Btu (mean)/min	0.05683
Joules (Int.)/sec	Cal. kg/min	0.01434
Joules (Int.)/sec	Horsepower	1.341×10^{-3}
Kilogram-meters	Btu (mean)	9.2878×10^{-3}
Kilogram-meters	Cal. kg (mean)	2.3405×10^{-3}
Kilogram-meters	Ergs	9.80665×10^7
Kilogram-meters	Foot-poundals	232.715
Kilogram-meters	Foot-pounds	7.233
Kilogram-meters	Hp-hours	3.653×10^{-6}
Kilogram-meters	Joules (Int.)	9.805
Kilogram-meters	kW-hours	2.724×10^{-6}
Kilogram-meters/sec	Watts	9.80665
Kilowatts (Int.)	Btu (IST.)/hr	3.413×10^3
Kilowatts (Int.)	Cal. kg (IST.)/hr	860.0
Kilowatts (Int.)	Ergs/sec	1.0002×10^{10}
Kilowatts (Int.)	Foot-poundals/min	1.424×10^6
Kilowatts (Int.)	Foot-pounds/min	4.4261×10^4
Kilowatts (Int.)	Horsepower (mechanical)	1.341
Kilowatts (Int.)	Horsepower (boiler)	0.10196
Kilowatts (Int.)	Horsepower (electric)	1.3407
Kilowatts (Int.)	Horsepower (metric)	1.3599
Kilowatts (Int.)	Joules (Int.)/hr	3.6×10^6
Kilowatts (Int.)	kg-meters/hr	3.6716×10^5
Kilowatt-hours (Int.)	Btu (mean)	3.41×10^3
Kilowatt-hours (Int.)	Foot-pounds	2.6557×10^6
Kilowatt-hours (Int.)	Hp-hours	1.341
Kilowatt-hours (Int.)	Joules (Int.)	3.6×10^6
Kilowatt-hours (Int.)	kg-meters	3.6716×10^5
Newton-meters	Gram-cm	1.01972×10^4
Newton-meters	kg-meters	0.101972

CONVERSION FACTORS (cont.).

To Convert From	To	Multiply By
Newton-meters	Pound-feet	0.73756
Force		
Dynes	Newtons	1.0×10^{-5}
Dynes	Poundals	7.233×10^{-5}
Dynes	Pounds	2.248×10^{-6}
Newtons	Dynes	1.0×10^{-5}
Newtons	Pounds (avdp.)	0.22481
Poundals	Dynes	1.383×10^4
Poundals	Newtons	0.1383
Poundals	Pounds (avdp.)	0.03108
Pounds (avdp.)	Dynes	4.448×10^5
Pounds (avdp.)	Newtons	4.448
Pounds (avdp.)	Poundals	32.174
Length		
Feet	Centimeters	30.48
Feet	Inches	12
Feet	Kilometers	3.048×10^{-4}
Feet	Meters	0.3048
Feet	Miles (statute)	1.894×10^{-4}
Inches	Centimeters	2.540
Inches	Feet	0.08333
Inches	Kilometers	2.54×10^{-5}
Inches	Meters	0.0254
Kilometers	Feet	3.2808×10^3
Kilometers	Meters	1000
Kilometers	Miles (statute)	0.62137
Kilometers	Yards	1.0936×10^3
Meters	Feet	3.2808
Meters	Inches	39.370
Micrometers	Angstrom units	1.0×10^4

CONVERSION FACTORS (cont.).

To Convert From	To	Multiply By
Micrometers	Centimeters	1.0×10^{-3}
Micrometers	Feet	3.2808×10^{-6}
Micrometers	Inches	3.9370×10^{-5}
Micrometers	Meters	1.0×10^{-6}
Micrometers	Millimeters	0.001
Micrometers	Nanometers	1000
Miles (statute)	Feet	5280
Miles (statute)	Kilometers	1.6093
Miles (statute)	Meters	1.6093×10^3
Miles (statute)	Yards	1760
Millimeters	Angstrom units	1.0×10^7
Millimeters	Centimeters	0.1
Millimeters	Inches	0.03937
Millimeters	Meters	0.001
Millimeters	Micrometers	1000
Millimeters	Mils	39.37
Nanometers	Angstrom units	10
Nanometers	Centimeters	1.0×10^{-7}
Nanometers	Inches	3.937×10^{-8}
Nanometers	Micrometers	0.001
Nanometers	Millimeters	1.0×10^{-6}
Yards	Centimeters	91.44
Yards	Meters	0.9144
Mass		
Grains	Grams	0.064799
Grains	Milligrams	64.799
Grains	Pounds (apoth. or troy)	1.7361×10^{-4}
Grains	Pounds (avdp.)	1.4286×10^{-4}
Grains	Tons (metric)	6.4799×10^{-8}
Grams	Dynes	980.67

CONVERSION FACTORS (cont.).

To Convert From	To	Multiply By
Grams	Grains	15.432
Grams	Kilograms	0.001
Grams	Micrograms	1×10^6
Grams	Pounds (avdp.)	2.205×10^{-3}
Grams	Tons, metric (megagrams)	1×10^{-6}
Kilograms	Grains	1.5432×10^4
Kilograms	Poundals	70.932
Kilograms	Pounds (apoth. or troy)	2.679
Kilograms	Pounds (avdp.)	2.2046
Kilograms	Tons (long)	9.842×10^{-4}
Kilograms	Tons (metric)	0.001
Kilograms	Tons (short)	1.1023×10^{-3}
Megagrams	Tons (metric)	1.0
Milligrams	Grains	0.01543
Milligrams	Grams	1.0×10^{-3}
Milligrams	Ounces (apoth. or troy)	3.215×10^{-5}
Milligrams	Ounces (avdp.)	3.527×10^{-5}
Milligrams	Pounds (apoth. or troy)	2.679×10^{-6}
Milligrams	Pounds (avdp.)	2.2046×10^{-6}
Ounces (apoth. or troy)	Grains	480
Ounces (apoth. or troy)	Grams	31.103
Ounces (apoth. or troy)	Ounces (avdp.)	1.097
Ounces (avdp.)	Grains	437.5
Ounces (avdp.)	Grams	28.350
Ounces (avdp.)	Ounces (apoth. or troy)	0.9115
Ounces (avdp.)	Pounds (apoth. or troy)	0.075955
Ounces (avdp.)	Pounds (avdp.)	0.0625
Pounds (avdp.)	Poundals	32.174
Pounds (avdp.)	Pounds (apoth. or troy)	1.2153
Pounds (avdp.)	Tons (long)	4.4643×10^{-4}

CONVERSION FACTORS (cont.).

To Convert From	To	Multiply By
Pounds (avdp.)	Tons (metric)	4.5359×10^{-4}
Pounds (avdp.)	Tons (short)	5.0×10^{-4}
Pounds (avdp.)	Grains	7000
Pounds (avdp.)	Grams	453.59
Pounds (avdp.)	Ounces (apoth. or troy)	14.583
Pounds (avdp.)	Ounces (avdp.)	16
Tons (long)	Kilograms	1.016×10^3
Tons (long)	Pounds (apoth. or troy)	2.722×10^3
Tons (long)	Pounds (avdp.)	2.240×10^3
Tons (long)	Tons (metric)	1.016
Tons (long)	Tons (short)	1.12
Tons (metric)	Grams	1.0×10^6
Tons (metric)	Megagrams	1.0
Tons (metric)	Pounds (apoth. or troy)	2.6792×10^3
Tons (metric)	Pounds (avdp.)	2.2046×10^3
Tons (metric)	Tons (long)	0.9842
Tons (metric)	Tons (short)	1.1023
Tons (short)	Kilograms	907.18
Tons (short)	Pounds (apoth. or troy)	2.4301×10^3
Tons (short)	Pounds (avdp.)	2000
Tons (short)	Tons (long)	0.8929
Tons (short)	Tons (metric)	0.9072
Pressure		
Atmospheres	cm of H ₂ O (4°C)	1.033×10^3
Atmospheres	Ft of H ₂ O (39.2°F)	33.8995
Atmospheres	In. of Hg (32°F)	29.9213
Atmospheres	kg/sq cm	1.033
Atmospheres	mm of Hg (0°C)	760
Atmospheres	Pounds/sq inch	14.696
Inches of Hg (60°F)	Atmospheres	0.03333

CONVERSION FACTORS (cont.).

To Convert From	To	Multiply By
Inches of Hg (60°F)	Grams/sq cm	34.434
Inches of Hg (60°F)	mm of Hg (60°F)	25.4
Inches of Hg (60°F)	Pounds/sq ft	70.527
Inches of H ₂ O (4°C)	Atmospheres	2.458×10^{-3}
Inches of H ₂ O (4°C)	In. of Hg (32°F)	0.07355
Inches of H ₂ O (4°C)	kg/sq meter	25.399
Inches of H ₂ O (4°C)	Pounds/sq ft	5.2022
Inches of H ₂ O (4°C)	Pounds/sq inch	0.036126
Kilograms/sq cm	Atmospheres	0.96784
Kilograms/sq cm	cm of Hg (0°C)	73.556
Kilograms/sq cm	Ft of H ₂ O (39.2°F)	32.809
Kilograms/sq cm	In. of Hg (32°F)	28.959
Kilograms/sq cm	Pounds/sq inch	14.223
Millimeters of Hg (0°C)	Atmospheres	1.3158×10^{-3}
Millimeters of Hg (0°C)	Grams/sq cm	1.3595
Millimeters of Hg (0°C)	Pounds/sq inch	0.019337
Pounds/sq inch	Atmospheres	0.06805
Pounds/sq inch	cm of Hg (0°C)	5.1715
Pounds/sq inch	cm of H ₂ O (4°C)	70.309
Pounds/sq inch	In. of Hg (32°F)	2.036
Pounds/sq inch	In. of H ₂ O (39.2°F)	27.681
Pounds/sq inch	kg/sq cm	0.07031
Pounds/sq inch	mm of Hg (0°C)	51.715
Velocity		
Centimeters/sec	Feet/min	1.9685
Centimeters/sec	Feet/sec	0.0328
Centimeters/sec	Kilometers/hr	0.036
Centimeters/sec	Meters/min	0.6
Centimeters/sec	Miles/hr	0.02237

CONVERSION FACTORS (cont.).

To Convert From	To	Multiply By
Feet/minute	cm/sec	0.508
Feet/minute	Kilometers/hr	0.01829
Feet/minute	Meters/min	0.3048
Feet/minute	Meters/sec	5.08×10^{-3}
Feet/minute	Miles/hr	0.01136
Feet/sec	cm/sec	30.48
Feet/sec	Kilometers/hr	1.0973
Feet/sec	Meters/min	18.288
Feet/sec	Miles/hr	0.6818
Kilometers/hr	cm/sec	27.778
Kilometers/hr	Feet/hr	3.2808×10^3
Kilometers/hr	Feet/min	54.681
Kilometers/hr	Meters/sec	0.27778
Kilometers/hr	Miles (statute)/hr	0.62137
Meters/min	cm/sec	1.6667
Meters/min	Feet/min	3.2808
Meters/min	Feet/sec	0.05468
Meters/min	Kilometers/hr	0.06
Miles/hr	cm/sec	44.704
Miles/hr	Feet/hr	5280
Miles/hr	Feet/min	88
Miles/hr	Feet/sec	1.4667
Miles/hr	Kilometers/hr	1.6093
Miles/hr	Meters/min	26.822
Volume		
Barrels (petroleum, U. S.)	Cu feet	5.6146
Barrels (petroleum, U. S.)	Gallons (U. S.)	42
Barrels (petroleum, U. S.)	Liters	158.98
Barrels (U. S., liq.)	Cu feet	4.2109
Barrels (U. S., liq.)	Cu inches	7.2765×10^3

CONVERSION FACTORS (cont.).

To Convert From	To	Multiply By
Barrels (U. S., liq.)	Cu meters	0.1192
Barrels (U. S., liq.)	Gallons (U. S., liq.)	31.5
Barrels (U. S., liq.)	Liters	119.24
Cubic centimeters	Cu feet	3.5315×10^{-5}
Cubic centimeters	Cu inches	0.06102
Cubic centimeters	Cu meters	1.0×10^{-6}
Cubic centimeters	Cu yards	1.308×10^{-6}
Cubic centimeters	Gallons (U. S., liq.)	2.642×10^{-4}
Cubic centimeters	Quarts (U. S., liq.)	1.0567×10^{-3}
Cubic feet	Cu centimeters	2.8317×10^4
Cubic feet	Cu meters	0.028317
Cubic feet	Gallons (U. S., liq.)	7.4805
Cubic feet	Liters	28.317
Cubic inches	Cu cm	16.387
Cubic inches	Cu feet	5.787×10^{-4}
Cubic inches	Cu meters	1.6387×10^{-5}
Cubic inches	Cu yards	2.1433×10^{-5}
Cubic inches	Gallons (U. S., liq.)	4.329×10^{-3}
Cubic inches	Liters	0.01639
Cubic inches	Quarts (U. S., liq.)	0.01732
Cubic meters	Barrels (U. S., liq.)	8.3864
Cubic meters	Cu cm	1.0×10^6
Cubic meters	Cu feet	35.315
Cubic meters	Cu inches	6.1024×10^4
Cubic meters	Cu yards	1.308
Cubic meters	Gallons (U. S., liq.)	264.17
Cubic meters	Liters	1000
Cubic yards	Bushels (Brit.)	21.022
Cubic yards	Bushels (U. S.)	21.696
Cubic yards	Cu cm	7.6455×10^5

CONVERSION FACTORS (cont.).

To Convert From	To	Multiply By
Cubic yards	Cu feet	27
Cubic yards	Cu inches	4.6656×10^4
Cubic yards	Cu meters	0.76455
Cubic yards	Gallons	168.18
Cubic yards	Gallons	173.57
Cubic yards	Gallons	201.97
Cubic yards	Liters	764.55
Cubic yards	Quarts	672.71
Cubic yards	Quarts	694.28
Cubic yards	Quarts	807.90
Gallons (U. S., liq.)	Barrels (U. S., liq.)	0.03175
Gallons (U. S., liq.)	Barrels (petroleum, U. S.)	0.02381
Gallons (U. S., liq.)	Bushels (U. S.)	0.10742
Gallons (U. S., liq.)	Cu centimeters	3.7854×10^3
Gallons (U. S., liq.)	Cu feet	0.13368
Gallons (U. S., liq.)	Cu inches	231
Gallons (U. S., liq.)	Cu meters	3.7854×10^{-3}
Gallons (U. S., liq.)	Cu yards	4.951×10^{-3}
Gallons (U. S., liq.)	Gallons (wine)	1.0
Gallons (U. S., liq.)	Liters	3.7854
Gallons (U. S., liq.)	Ounces (U. S., fluid)	128.0
Gallons (U. S., liq.)	Pints (U. S., liq.)	8.0
Gallons (U. S., liq.)	Quarts (U. S., liq.)	4.0
Liters	Cu centimeters	1000
Liters	Cu feet	0.035315
Liters	Cu inches	61.024
Liters	Cu meters	0.001
Liters	Gallons (U. S., liq.)	0.2642
Liters	Ounces (U. S., fluid)	33.814

CONVERSION FACTORS (cont.).

To Convert From	To	Multiply By
Volumetric Rate		
Cu ft/min	Cu cm/sec	471.95
Cu ft/min	Cu ft /hr	60. 0
Cu ft/min	Gal (U. S.)/min	7.4805
Cu ft/min	Liters/sec	0.47193
Cu meters/min	Gal (U. S.)/min	264.17
Cu meters/min	Liters/min	999.97
Gallons (U. S.)/hr	Cu ft/hr	0.13368
Gallons (U. S.)/hr	Cu meters/min	6.309×10^{-5}
Gallons (U. S.)/hr	Cu yd/min	8.2519×10^{-5}
Gallons (U. S.)/hr	Liters/hr	3.7854
Liters/min	Cu ft/min	0.0353
Liters/min	Gal (U. S., liq.)/min	0.2642

^a Where appropriate, the conversion factors appearing in this table have been rounded to four to six significant figures for ease in use. The accuracy of these numbers is considered suitable for use with emissions data; if a more accurate number is required, tables containing exact factors should be consulted.

CONVERSION FACTORS FOR COMMON AIR POLLUTION MEASUREMENTS

AIRBORNE PARTICULATE MATTER

To Convert From	To	Multiply By
Milligrams/cu m	Grams/cu ft	283.2×10^{-6}
	Grams/cu m	0.001
	Micrograms/cu m	1000.0
	Micrograms/cu ft	28.32
	Pounds/1000 cu ft	62.43×10^{-6}
Grams/cu ft	Milligrams/cu m	35.3145×10^3
	Grams/cu m	35.314
	Micrograms/cu m	35.314×10^6
	Micrograms/cu ft	1.0×10^6
	Pounds/1000 cu ft	2.2046
Grams/cu m	Milligrams/cu m	1000.0
	Grams/cu ft	0.02832
	Micrograms/cu m	1.0×10^6
	Micrograms/cu ft	28.317×10^3
	Pounds/1000 cu ft	0.06243
Micrograms/cu m	Milligrams/cu m	0.001
	Grams/cu ft	28.317×10^{-9}
	Grams/cu m	1.0×10^{-6}
	Micrograms/cu ft	0.02832
	Pounds/1000 cu ft	62.43×10^{-9}
Micrograms/cu ft	Milligrams/cu m	35.314×10^{-3}
	Grams/cu ft	1.0×10^{-6}
	Grams/cu m	35.314×10^{-6}
	Micrograms/cu m	35.314
	Pounds/1000 cu ft	2.2046×10^{-6}
Pounds/1000 cu ft	Milligrams/cu m	16.018×10^3
	Grams/cu ft	0.35314
	Micrograms/cu m	16.018×10^6
	Grams/cu m	16.018
	Micrograms/cu ft	353.14×10^3

CONVERSION FACTORS FOR COMMON AIR POLLUTION MEASUREMENTS (cont.).

SAMPLING PRESSURE

To Convert From	To	Multiply By
Millimeters of mercury (0°C)	Inches of water (60°F)	0.5358
Inches of mercury (0°C)	Inches of water (60°F)	13.609
	Millimeters of mercury (0°C)	1.8663
Inches of water (60°F)	Inches of mercury (0°C)	73.48×10^{-3}

CONVERSION FACTORS FOR COMMON AIR POLLUTION MEASUREMENTS (cont.).

ATMOSPHERIC GASES

To Convert From	To	Multiply By
Milligrams/cu m	Micrograms/cu m	1000.0
	Micrograms/liter	1.0
	ppm by volume (20°C)	24.04/M
	ppm by weight	0.8347
	Pounds/cu ft	62.43×10^{-9}
Micrograms/cu m	Milligrams/cu m	0.001
	Micrograms/liter	0.001
	ppm by volume (20°C)	0.02404/M
	ppm by weight	834.7×10^{-6}
	Pounds/cu ft	62.43×10^{-12}
Micrograms/liter	Milligrams/cu m	1.0
	Micrograms/cu m	1000.0
	ppm by volume (20°C)	24.04/M
	ppm by weight	0.8347
	Pounds/cu ft	62.43×10^{-9}
ppm by volume (20°C)	Milligrams/cu m	M/24.04
	Micrograms/cu m	M/0.02404
	Micrograms/liter	M/24.04
	ppm by weight	M/28.8
	Pounds/cu ft	$M/385.1 \times 10^6$
ppm by weight	Milligrams/cu m	1.198
	Micrograms/cu m	1.198×10^{-3}
	Micrograms/liter	1.198
	ppm by volume (20°C)	28.8/M
	Pounds/cu ft	7.48×10^{-6}
Pounds/cu ft	Milligrams/cu m	16.018×10^6
	Micrograms/cu m	16.018×10^9
	Micrograms/liter	16.018×10^6
	ppm by volume (20°C)	$385.1 \times 10^6/M$
	ppm by weight	133.7×10^3

M = Molecular weight of gas.

CONVERSION FACTORS FOR COMMON AIR POLLUTION MEASUREMENTS (cont.).

VELOCITY

To Convert From	To	Multiply By
Meters/sec	Kilometers/hr	3.6
	Feet/sec	3.281
	Miles/hr	2.237
Kilometers/hr	Meters/sec	0.2778
	Feet/sec	0.9113
	Miles/hr	0.6214
Feet/sec	Meters/sec	0.3048
	Kilometers/hr	1.09728
	Miles/hr	0.6818
Miles/hr	Meters/sec	0.4470
	Kilometers/hr	1.6093
	Feet/sec	1.4667

ATMOSPHERIC PRESSURE

To Convert From	To	Multiply By
Atmospheres	Millimeters of mercury	760.0
	Inches of mercury	29.92
	Millibars	1013.2
Millimeters of mercury	Atmospheres	1.316×10^{-3}
	Inches of mercury	39.37×10^{-3}
	Millibars	1.333
Inches of mercury	Atmospheres	0.03333
	Millimeters of mercury	25.4005
	Millibars	33.35
Millibars	Atmospheres	0.00987
	Millimeters of mercury	0.75
	Inches of mercury	0.30

VOLUME EMISSIONS

To Convert From	To	Multiply By
Cubic m/min	Cubic ft/min	35.314
Cubic ft/min	Cubic m/min	0.0283

BOILER CONVERSION FACTORS

1 Megawatt	=	10.5 x 10 ⁶ Btu/hr (8 to 14 x 10 ⁶ Btu/hr)	NOTES: In the relationships,
1 Megawatt	=	8 x 10 ³ lb steam/hr (6 to 11 x 10 ³ lb steam/hr)	Megawatt is the net electric production of a steam electric power plant.
1 BHP	=	34.5 lb steam/hr	BHP is boiler horsepower.
1 BHP	=	45 x 10 ³ Btu/hr (40 to 50 x 10 ³ Btu/hr)	lb steam/hr is the steam production rate of the boiler.
1 lb steam/hr	=	1.4 x 10 ³ Btu/hr (1.2 to 1.7 x 10 ³ Btu/hr)	Btu/hr is the heat input rate to the boiler (based on the gross or high heating value of the fuel burned).

For less efficient (generally older and/or smaller) boiler operations, use the higher values expressed. For more efficient operations (generally newer and/or larger), use the lower values.

Volume	cu in	ml	liters	ounces (U. S. fl.)	gallons (U. S.)	barrels (U. S.)	cu ft
Cubic inches		16.3868	0.0163868	0.5541	4.3290x10 ⁻³	1.37429x10 ⁻⁴	5.78704x10 ⁻⁴
Milliliters	0.061024		0.001	0.03381	2.6418x10 ⁻⁴	8.387x10 ⁻⁶	3.5316x10 ⁻⁵
Liters	61.024	1000		33.8147	0.26418	8.387x10 ⁻³	0.035316
Ounces (U. S. fl.)	1.80469	29.5729	0.029573		7.8125x10 ⁻³	2.48x10 ⁻⁴	1.0443x10 ⁻³
Gallons (U. S.) ^a	231	3785.3	3.7853	128		0.031746	0.13368
Barrels (U. S.)	7276.5	1.1924x10 ⁵	119.2369	4032.0	31.5		4.2109
Cubic feet	1728	2.8316x10 ⁴	28.316	957.568	7.481	0.23743	

^a U. S. gallon of water at 16.7°C (62°F) weighs 3.780 kg or 8.337 pounds (avoir.)

Mass	grams	kilograms	ounces (avoir.)	pounds (avoir.)	grains	tons (U. S.)	milligrams
Grams		0.001	3.527x10 ⁻²	2.205x10 ⁻³	15.432	1.102x10 ⁻⁶	1000
Kilograms	1000		35.274	2.2046	15432	1.102x10 ⁻³	1x10 ⁶
Ounces (avoir.)	28.350	0.028350		0.0625	437.5	3.125x10 ⁻⁵	2.8350x10 ⁴
Pounds (avoir.) ^a	453.59	0.45359	16.0		7000	5.0x10 ⁻⁴	4.5359x10 ⁵
Grains	0.06480	6.480x10 ⁻⁵	2.286x10 ⁻³	1.429x10 ⁻⁴		7.142x10 ⁻⁸	64.799
Tons (U. S.)	9.072x10 ⁵	907.19	3.200x10 ⁴	2000	1.4x10 ⁷		9.0718x10 ⁸
Milligrams	0.001	1x10 ⁻⁶	3.527x10 ⁻⁵	2.205x10 ⁻⁶	0.015432	1.102x10 ⁻⁹	

^a Mass of 27.692 cubic inches water weighed in air at 4.0°C, 760 mm mercury pressure.

Work and Energy	g cal.	kg cal.	ergs	joules	Btu	ft lb	kg meters	L-Atm	HP hours	ft poundals	kWh	Wh
Gram calories (mean)		0.001	4.186x10 ⁷	4.186	3.9680x10 ⁻³	3.0874	0.42685	0.041311	1.5593x10 ⁻⁶	99.334	1.1628x10 ⁻⁶	1.1628x10 ⁻³
Kilogram calories	1000		4.186x10 ¹⁰	4186	3.9680	3087.4	426.85	41.311	1.5593x10 ⁻³	99334	1.1628x10 ⁻³	1.1628
Ergs	2.3889x10 ⁻⁸	2.3889x10 ⁻¹¹		1x10 ⁻⁷	9.4805x10 ⁻¹¹	7.3756x10 ⁻⁸	1.0197x10 ⁻⁸	9.8689x10 ⁻¹⁰	3.7251x10 ⁻¹⁴	2.3730x10 ⁻⁶	2.7778x10 ⁻¹⁴	2.7778x10 ⁻¹¹
Joules	0.23889	2.3889x10 ⁻⁴	1x10 ⁷		9.4805x10 ⁻⁴	0.73756	0.10197	9.8689x10 ⁻³	3.7251x10 ⁻⁷	23.730	2.7778x10 ⁻⁷	2.7778x10 ⁻⁴
Btu (mean)	251.98	0.25198	1.0548x10 ¹⁰	1054.8		777.98	107.56	10.409	3.9292x10 ⁻⁴	2.5030x10 ⁴	2.930x10 ⁻⁴	0.2930
Foot pounds	0.32389	3.2389x10 ⁻⁴	1.35582x10 ⁷	1.3558	1.2854x10 ⁻³		0.13825	0.013381	5.0505x10 ⁻⁷	32.174	3.7662x10 ⁻⁷	3.7662x10 ⁻⁴
Kilogram meters	2.3427	2.3427x10 ⁻³	9.8066x10 ⁷	9.8066	9.2967x10 ⁻³	7.2330		0.096781	3.6529x10 ⁻⁶	232.71	2.7241x10 ⁻⁶	2.7241x10 ⁻³
Liter atmospheres (normal)	24.206	2.4206x10 ⁻²	1.0133x10 ⁹	101.328	0.09606	74.735	10.333		3.7745x10 ⁻⁵	2404.5	2.8164x10 ⁻⁵	2.8164x10 ⁻²
Horsepower hours	6.4130x10 ⁵	641.30	2.6845x10 ¹³	2.6845x10 ⁶	2454.0	1.9800x10 ⁶	2.7374x10 ⁵	26494		6.3705x10 ⁷	0.7457	745.7
Foot poundals	0.010067	10.067x10 ⁻⁶	4.21402x10 ⁵	0.04214	3.9952x10 ⁻⁵	0.031081	4.2972x10 ⁻³	4.1558x10 ⁻⁴	1.5697x10 ⁻⁸		1.17055x10 ⁻⁸	1.17055x10 ⁻⁵
Kilowatt hours	8.6001x10 ⁵	860.01	3.6000x10 ¹³	3.6000x10 ⁶	3413.0	2.6552x10 ⁶	3.6709x10 ⁻⁵	3.5529x10 ⁶	1.3440	8.5430x10 ⁷		1000
Watt hours	860.01	0.86001	3.6000x10 ¹⁰	3600	3.4130	2655.3	367.09	3.5529x10 ³	1.3410x10 ⁻³	8.5430x10 ¹	0.001	

Power	watts	kW	ft lb/sec	erg/sec	Btu/min	g cm/sec	kg cal/min	HP	lumens	joules/sec	Btu/hr
Watts		0.001	0.73756	1×10^7	0.056884	1.0197×10^4	0.01433	1.341×10^{-3}	668	1	3.41304
Kilowatts	1000		737.56	1×10^{10}	56.884	1.0197×10^7	14.3334	1.3410	6.68×10^5	1000	3413.04
Foot pounds per second	1.35582	1.3558×10^{-3}		1.3558×10^7	0.077124	1.3826×10^4	0.019433	1.8182×10^{-3}	906.28	1.3558	4.6274
Ergs per second	1×10^{-7}	1×10^{-10}	7.3756×10^{-8}		5.688×10^{-9}	1.0197×10^{-3}	1.4333×10^{-9}	1.3410×10^{-10}	6.6845×10^{-5}	1×10^{-7}	3.4130×10^{-7}
Btu ^a per minute	17.580	0.017580	12.9600	1.7580×10^8		1.7926×10^5	0.2520	0.023575	11751	17.580	60
Gram centimeters per second	9.8067×10^{-5}	9.8067×10^{-8}	7.2330×10^{-5}	980.665	5.5783×10^{-6}		1.4056×10^{-6}	1.3151×10^{-7}	0.065552	9.8067×10^{-5}	3.3470×10^{-4}
Kilogram calories per minute	69.767	0.069767	51.457	6.9770×10^8	3.9685	7.1146×10^5		0.093557	46636	69.769	238.11
Horsepower (U. S.)	745.7	0.7457	550	7.457×10^9	42.4176	7.6042×10^6	10.688		498129	745.7	2545.1
Lumens	1.496×10^{-3}	1.496×10^{-6}	1.0034×10^{-3}	1.496×10^4	8.5096×10^{-5}	15.254	2.1437×10^{-5}	2.0061×10^{-6}		1.496×10^{-3}	5.1069×10^{-3}
Joules per second	1	0.001	0.73756	1×10^7	0.056884	1.0197×10^4	0.01433	1.341×10^{-3}	668		3.41304
Btu ^a per hour	0.29299	2.9299×10^{-4}	0.21610	2.9299×10^6	0.01667	2.9878×10^3	4.1997×10^{-3}	3.9291×10^{-4}	195.80	0.29299	

^a British Thermal Units (Mean)

CONVERSION FACTORS FOR VARIOUS SUBSTANCES^a

Type Of Substance	Conversion Factors
Fuel	
Oil	1 bbl = 159 liters (42 gal)
Natural gas	1 therm = 100,000 Btu (approx.25000 kcal)
Gaseous Pollutants	
O ₃	1 ppm, volume = 1960µg/m ³
NO ₂	1 ppm, volume = 1880µg/m ³
SO ₂	1 ppm, volume = 2610µg/m ³
H ₂ S	1 ppm, volume = 1390 µg/m ³
CO	1 ppm, volume = 1.14 mg/m ³
HC (as methane)	1 ppm, volume = 0.654 mg/m ³
Agricultural products	
Corn	1 bu = 25.4 kg = 56 lb
Milo	1 bu = 25.4 kg = 56 lb
Oats	1 bu = 14.5 kg = 32 lb
Barley	1 bu = 21.8 kg = 48 lb
Wheat	1 bu = 27.2 kg = 60 lb
Cotton	1 bale = 226 kg = 500 lb
Mineral products	
Brick	1 brick = 2.95 kg = 6.5 lb
Cement	1 bbl = 170 kg = 375 lb
Cement	1 yd ³ = 1130 kg = 2500 lb
Concrete	1 yd ³ = 1820 kg = 4000 lb
Mobile sources, fuel efficiency	
Motor vehicles	1.0 mi/gal = 0.426 km/liter
Waterborne vessels	1.0 gal/naut mi = 2.05 liters/km
Miscellaneous liquids	
Beer	1 bbl = 31.5 gal
Paint	1 gal = 4.5 to 6.82 kg = 10 to 15 lb
Varnish	1 gal = 3.18 kg = 7 lb
Whiskey	1 bbl = 190 liters = 50.2 gal
Water	1 gal = 3.81 kg = 8.3 lb

^a Many of the conversion factors in this table represent average values and approximations and some of the values vary with temperature and pressure. These conversion factors should, however, be sufficiently accurate for general field use.

APPENDIX C

CONTACT AND RESOURCE INFORMATION

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1. Office of Air Quality Planning and Standards Technology Transfer Network (TTN) Electronic Bulletin Board (OAQPS TTN)

The OAQPS TTN provides access to the *Emission Measurement Technical Information Center (EMTIC)* and *Clearinghouse for Inventories and Emission Factors (CHIEF)* bulletin boards.

OAQPS TTN System Operators:

Herschel Rorex, System Manager
Phil Dickerson, Assistant System Manager
Research Triangle Park, NC 27711
(919) 541-5384

TTN Telephone:

(919) 541-5742 (1200, 2400, or 9600 baud)

FTP site:

ttnftp.rtpnc.epa.gov

Internet:

ttnwww.rtpnc.epa.gov

Telenet:

ttnbbs.rtpnc.epa.gov

Hardware and Software Requirements

Computer

Communications software package

Modem

Communications software parameters:

8 data bits

1 stop bit

no parity

full duplex

terminal emulation VT100 or VT/ANSI

The OAQPS TTN is down every Monday morning from 8:00 a.m. to 12:00 p.m. EST for maintenance.

2. Emission Factor Assistance Line (InfoCHIEF) for questions pertaining to SPECIATE, FIRE, AIRS SCC/SIC file, Air CHIEF CD-ROM, Fax CHIEF, CHIEF

Bulletin Board, TANKS, L&E documents, or AP-42

Address:

Emission Factor and Inventory Group (MD-14)
U.S. Environmental Protection Agency
Research Triangle Park, NC 27711

Contact:

InfoCHIEF Help Line

Telephone:

(919) 541-5285

Fax CHIEF:

(919) 541-0548
(919) 541-5626

3. New SCC Assignments

Address:

Emission Factor and Inventory Group (MD-14)
U.S. Environmental Protection Agency
Research Triangle Park, NC 27711

Contact:

Ron Ryan

Telephone:

(919) 541-4330

4. Air Pollution Training Institute

Address:

Environmental Research Center
U.S. Environmental Protection Agency
Research Triangle Park, NC 27711

Contact:

J. Nunn, Training Coordinator

Telephone:
(919) 541-3724

5. Information on CHEMDAT8 and WATER8

Address:
Emission Standards Division
U.S. Environmental Protection Agency
Research Triangle Park, NC 27711

Contact:
Elaine Manning

Telephone:
(919) 541-5499

6. Information on LAEEM

Address:
Air Pollution Prevention and Control Division
Office of Research and Development
U.S. Environmental Protection Agency
Research Triangle Park, NC 27711

Contact:
Susan Thorneloe

Telephone:
(919) 541-2709

7. U.S. Environmental Protection Agency Library

Single copies of some EPA documents and personal computer tools are available free to government and non-profit organizations from the EPA library. For-profit organizations should order from the Government Printing Office (GPO) or from the National Technical Information Service (NTIS).

Address:
U.S. Environmental Protection Agency Library
MD-35
Research Triangle Park, NC 27711

Telephone:
(919) 541-2777

8. Government Printing Office (GPO)

Address:
Government Printing Office
Superintendent of Documents
P.O. Box 371954
Pittsburgh, PA 15250-795420402

Telephone:
(202) 512-1800
(202) 512-2250 (Fax)

9. National Technical Information Service (NTIS)

Address:
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161

Ordering and Catalog Information:
(703) 487-4650
(703) 321-8547 (fax)
(800) 553-6847 (rush orders only)

Telecommunications Devices for the Deaf (TDD):
(703) 487-4639

NTIS documents are generally available on paper or microfiche.

10. Pollution Prevention Information Clearinghouse

Telephone:

(202) 260-1023

Pollution Prevention Information Exchange System (PIES)

(access via computer)

(703) 506-1025

Hardware and Software Requirements

Computer

Communications software package

Modem

Communications software parameters:

8 data bits

1 stop bit

no parity

11. Control Technology Center

Address:

U.S. Environmental Protection Agency

ORD/APPCD (MD-91) or

OAQPS/ITPID (MD-12)

Air Pollution Prevention and Control Division

MD-91

Research Triangle Park, NC 27711

Telephone:

(919) 541-0800

12. Emergency Planning and Community Right-to-Know Act Hotline

(703) 412-9810

(800) 424-9346

Telecommunications Devices for the Deaf (TDD): (800) 553-7672

13. EIIP Point Sources Committee**Co-chairs**

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APPENDIX D

ANNUAL EMISSIONS INVENTORY CHECKLIST FOR STATIONARY POINT SOURCES

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ANNUAL EMISSIONS INVENTORY CHECKLIST FOR STATIONARY POINT SOURCES

Completeness Checks - Point Sources	Yes	No	Comments
Have all VOC point sources with actual emissions ≥ 10 tpy been included in the inventory?			
Have process, point, and segment level data been provided for all VOC point sources with actual emissions ≥ 10 tpy?			
Have all VOC sources in the 25-mile zone outside of the nonattainment area with emissions >100 tpy been addressed in the inventory?			
Have all NO_x and CO sources in the nonattainment area and 25-mile zone outside of the nonattainment area with emissions >100 tpy been addressed in the inventory?			
Have all process, point, and segment level documentation data required for the 100-ton NO_x and CO sources been provided?			
Does the inventory include point sources for VOCs in the 10 - 25 tpy (actual) range?			
Are the following VOC point source categories represented among the 10 - 25 tpy plant listings?			
<i>Note: Provide documentation if any are "no."</i>			
• Graphic Arts			
• Commercial/Institutional Boilers			
• Industrial Boilers			
• Gasoline Bulk Plants			

ANNUAL EMISSIONS INVENTORY CHECKLIST FOR STATIONARY POINT SOURCES**(CONTINUED)**

Completeness Checks - Point Sources	Yes	No	Comments
• Degreasing Operations			
• Waste Disposal/Treatment			
Are the following broad source categories represented among the >25 tpy VOC plant listing?			
• Storage, transportation and marketing of petroleum products and volatile organic liquids			
• Industrial Processes			
• Industrial Surface Coating			
Are the following CO and NO _x source categories represented among the plant listings?			
• Utility Boilers			
• Industrial Boilers			
• Commercial/Institutional External Fuel Combustion			
• Waste Disposal/Combustion			
Is the annual emission inventory signed by the proper authority who will take legal responsibility for the accuracy of the information verified in the report to the state?			
Is the following information provided in the report (to the state) and is it accurate: source addresses, contact information, and SIC code(s)?			

ANNUAL EMISSIONS INVENTORY CHECKLIST FOR STATIONARY POINT SOURCES

(CONTINUED)

Procedures Checks(Continued)	Yes	No	Comments
Have you made a copy of the inventory and report you are mailing to the state agency?			
Does the inventory documentation describe the methodology used (i.e., survey, plant inspections, continuous emissions monitoring data, fuel analysis data, air quality modeling data, material balance, AFS, and permit files) to develop the point source inventory listing?			
Does the point source inventory reflect a base year of 1990? <i>Note: If another inventory was used as a starting point, documentation should be provided to show what adjustments were made to reflect the 1990 base year.</i>			
Were emissions estimates adjusted to reflect the O ₃ season and rule effectiveness?			
Does the inventory documentation describe the methodology used to define months of the O ₃ season?			
Indicate which of the following basic options were used to submit data for point sources:			
• EIIP data transfer format			
• AFS batch transaction format			
• Interactive direct entry to AFS			
Was a computer model used to estimate emissions from waste treatment/disposal sources? If yes, which model?			

ANNUAL EMISSIONS INVENTORY CHECKLIST FOR STATIONARY POINT SOURCES**(CONTINUED)**

Procedures Checks (Continued)	Yes	No	Comments
Was a rule effectiveness factor of 80 percent used for all categories?			
Does the point source inventory documentation include the contact person(s) for referring questions?			
Was rule effectiveness applied to emission estimates for the following point source categories?			
• Surface Coating of Cans			
• Surface Coating of Metal Coils			
• Surface Coating of Fabric and Vinyl			
• Surface Coating of Paper Products			
• Coating of Automobiles and Light-duty Trucks in Assembly Plants			
• Surface Coating of Metal Furniture			
• Surface Coating of Magnetic Wire			
• Tank Truck Gasoline Loading Terminals			
• Bulk Gasoline Plants			

ANNUAL EMISSIONS INVENTORY CHECKLIST FOR STATIONARY POINT SOURCES**(CONTINUED)**

Procedures Checks (Continued)	Yes	No	Comments
Select a subset that represents at least 10 percent of the listed point sources (in the >25 tpy range) and determine if the following data are compiled and presented for each source. <i>Note: Identify in the comment column the record number of those plants that were checked.</i>			
• Plant name and location (including latitude, longitude, and zip code)			
• AFS point ID			
• SIC code(s)			
• Operating schedule			
• Applicable regulations			
• Current environmental permits			
• UTM zone			
• FIP State, city, and county codes			
• Plot plan of the facility			
• Pollutant code or CAS code			
• Inventory of vents and stacks (for point pollutant data)			
• Stack parameter data			
• Emission limitations (only if subject to SIP regulation)			

ANNUAL EMISSIONS INVENTORY CHECKLIST FOR STATIONARY POINT SOURCES**(CONTINUED)**

Reasonableness Checks	Yes	No	Comments
• Compliance year (only if subject to SIP Regulation)			
• SCC for process unit			
• Daily process rate and units			
• Listing and description of processes and support activities			
• Listing of cooling units and air conditioners using CFCs			
• Type and volume of CFC used			
• Control equipment type			
• Control efficiency			
• Date of equipment installation and latest modification			
• Emissions estimation method			
• Emission factors			
• List, description, and volume of wastes generated			
• Chemical and fuel storage tank data			
• Current emission source testing results			
• Material safety data sheets for production and maintenance-related raw materials			
• Rule effectiveness			
• Seasonal adjustment factor			

ANNUAL EMISSIONS INVENTORY CHECKLIST FOR STATIONARY POINT SOURCES

(CONTINUED)

Reasonableness Checks (Continued)	Yes	No	Comments
<ul style="list-style-type: none"> O₃ season daily emissions 			
Does the sum of emission estimates from small VOC point sources represent at least 5 percent of the total point source VOC contribution?			
If point source VOC emissions are attributed to the synthetic organic chemical manufacturing industry (SOCMI), are fugitive leaks also quantified? <i>Note: Fugitive equipment leak emissions should be 1 to 10 times larger than emissions from vents, reactors, etc.</i>			
Are unadjusted annual emissions estimates for VOC, CO, and NO _x from point sources within 25 percent of the values reported in AFS?			
Are the following data elements within the ranges listed below for general point sources data?			
<ul style="list-style-type: none"> Hours per day ≤ 24 			
<ul style="list-style-type: none"> Days per week ≤ 7 			
<ul style="list-style-type: none"> Hours per year $\leq 8,760$ 			
<ul style="list-style-type: none"> Seasonal throughputs 0 - 100 			
<ul style="list-style-type: none"> Boiler capacity 80 - 120 percent of hourly maximum rate x fuel heat content 			
<ul style="list-style-type: none"> Is percent space heat for winter greater than summer 			

ANNUAL EMISSIONS INVENTORY CHECKLIST FOR STATIONARY POINT SOURCES**(CONTINUED)**

Reasonableness Checks (Continued)	Yes	No	Comments
Are the following data elements within the ranges listed below for point pollutant data?			
• Stack height >50 Feet			
• Stack diameter 0.5 and 30 Feet			
• Plume height >200 Feet			
• Temperature of exit gases between 60°F and 2,000°F			
• Temperature of exit gases with wet scrubber <250°F			
• Temperature of exit gases without wet scrubber >250°F			
• Exhaust gas flow rate and velocity within expected range?			
Are the following data elements within the ranges listed below for general segment data?			
• For control devices, is the control efficiency between 0 - 100 percent?			
• Are emission estimates within the ranges expected?			

APPENDIX E

TEST METHODS

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This appendix describes available pollutant monitoring and fuel analysis methodologies. Table 1.E-1 contains a listing of the published and approved methodologies available for determining pollutant emissions using stack test data. Continuous emission monitoring (CEM), manual monitoring, and fuel analysis are included. A description of each method listed in Table 1.E-1 is discussed below. Section E.1 summarizes EPA methods and section E.2 addresses other (i.e., non-EPA methods).

E.1 EPA METHODS

E.1.1 EPA METHOD 2 (STACK SAMPLING)

This method is applicable for measurement of the average velocity of a gas stream and for quantifying gas flow rate. The average gas velocity is determined from the gas density and from measurement of the average velocity head with a Type S (Staustscheibe or reverse type) pitot tube. Gas velocity is then multiplied by the cross-sectional area of the stack or duct to determine volumetric gas flow rate. This method cannot be used for direct measurement in cyclonic or swirling gas streams.

E.1.2 EPA METHOD 3 (STACK SAMPLING)

This method is used to determine oxygen (O_2) and carbon dioxide (CO_2) concentrations in flue gas from fossil-fuel-fired combustion processes. A gas sample is extracted from the stack either from a single point or by multipoint integrated sampling. The sample is passed through an Orsat analyzer containing a solution of 45-percent potassium hydroxide (KOH) in one impinger and a solution of pyrogallol in the second impinger. The CO_2 is absorbed by KOH, and the O_2 is absorbed by pyrogallol. The decrease in sample volume due to this absorption is directly proportional to the concentration in the sample.

E.1.3 EPA METHOD 3A (CEM)

This method may be used to determine O_2 and CO_2 concentrations when CEM systems are in place. A gas sample is extracted continuously from the stack and conveyed to the O_2 and CO_2 analyzers. The sample can be wet or dry depending on the type of analyzer used.

CO_2 can only be measured using infrared analyzers such as nondispersive infrared (NDIR) systems or gas filter correlation (GFC) analyzers.

NDIR analyzers consist of sample and reference optical cells through which a beam of infrared light passes. This beam of light is modulated so that the infrared light passing through the optical cell pulses. The modulated infrared light then enters a two-chambered detector that is

TABLE 1.E-1

SUMMARY OF AVAILABLE MONITORING AND FUEL ANALYSIS METHODS

Parameter	Monitoring Methods		Fuel Analysis Method
	Stack Sampling	CEM	
SO ₂	EPA Method 6	EPA Method 6C	ASTM D-1552-83/ D4507-81 ^a
SO ₃	EPA Method 8	NA	
NO _x	EPA Method 7	EPA Method 7E	
O ₂ /CO ₂	EPA Method 3	EPA Method 3A	
CO	EPA Method 10B	EPA Method 10	
VOC	EPA Method 25	NA	
THC	EPA Method 25	EPA Method 25A	
Speciated organics	EPA Method 0030	NA	
Heavy metals	EPA Method 29	NA	SW 846 Methods 3040/7090 ^b
PM	EPA Method 5	NA	
PM ₁₀	EPA Method 201/202	NA	
Sulfuric acid mist	EPA Method 8	NA	
Flow rate	EPA Method 2	EPA Method 19, CFRM ^c	

Sources: EPA, 1986; *Test Methods for Evaluating Solid Waste*, SW-846, Third Edition; ASTM, 1992; Title 40 CFR, Appendices A and B, September 1992. Title 40 CFR Part 60, Appendix A and Part 61, Appendix B.

^a For liquid fuels. ASTM D3177-75/D4239-85 is used for coal.

^b For liquid fuels.

^c Continuous flow rate monitoring.

NA = Not applicable; no CEM method exists.

filled with the same gas that is being analyzed. The gas in the detector chambers absorbs the infrared light and heats up, causing it to expand. Separating the two chambers is a thin diaphragm which flexes as the pressure between the two chambers varies. Since the sample has absorbed some of the infrared light, the detector chamber associated with the sample cell does not heat up as much as the reference side. This causes a pressure differential between the two chambers, deflecting the diaphragm. Because the infrared light is modulated, the diaphragm pulses. This degree of deflection in conjunction with the pulsing is converted into an electrical signal proportional to gas concentration.

O₂ analyzers generally use electrochemical cells. Porous platinum electrodes are attached to the inside and outside of the cell to provide the instrument voltage response. Zirconium oxide contained in the cell conducts electrons when it is hot due to the mobility of O₂ ions in its crystal structure. A difference in O₂ concentration between the sample side of the cell and the reference (outside) side of the cell produces a voltage. This response is proportional to the logarithm of the O₂ concentration ratio. The reference gas is ambient air at 20.9 percent O₂ by volume.

E.1.4 EPA METHOD 5 OR 17 (STACK SAMPLING)

EPA Method 5 or 17 may be used to monitor emissions of particulate matter (PM) from boilers. In Method 5, PM is withdrawn isokinetically from the source and collected externally on a heated glass fiber filter maintained at 248°F ± 25°F. Method 17 employs an in-stack filter and particulate matter is collected at source temperature and pressure. The particulate mass is determined gravimetrically.

E.1.5 EPA METHOD 6 (STACK SAMPLING)

Method 6 is used to measure SO₂ emissions. A gas sample is extracted from the sampling point in the stack. The sample passes through a filter to remove PM and the sulfuric acid (including sulfur trioxide) and sulfur dioxide (SO₂) are separated in a series of impingers containing 80 percent isopropanol and 3 percent hydrogen peroxide. The SO₂ is then measured by barium-thorin titration.

E.1.6 EPA METHOD 6C (CEM)

Method 6 is used to measure SO₂ emissions when CEM systems are in place. A gas sample is continuously extracted from a stack, and a portion of the sample is conveyed to a continuous analyzer for determination of SO₂ gas concentration using an NDIR, ultraviolet (UV), or fluorescence analyzer.

NDIR analyzers were discussed in section E.1.3.

UV analyzers work very similarly to NDIR instruments. A beam of UV light passes through the gas sample, which absorbs some of the light. The remaining light passes through the sample cell and is measured by the detector.

Fluorescence analyzers are typically used in ambient monitoring. The analyzer works by exposing the sample to a pulse of ultraviolet light. SO_2 molecules absorb this light, which "excites" the molecule into a higher energy state. The molecule loses some of this excess energy by fluorescing (detected by a photomultiplier tube), which in turn provides an SO_2 concentration value.

E.1.7 EPA METHOD 7 (STACK SAMPLING)

Method 7 is used to measure NO_x emissions. A grab sample is collected in an evacuated flask containing a dilute sulfuric acid-hydrogen peroxide absorbing solution, and the NO_x , except nitrous oxide (N_2O), are measured colorimetrically using phenoldisulfonic acid (PDS).

E.1.8 EPA METHOD 7E (CEM)

When CEM systems are in place, Method 7E is used. A gas sample is continuously extracted from the stack and a portion of the sample is conveyed to an instrumental chemiluminescent analyzer for determination of NO_x concentration. This measurement technique uses a chemical reaction (ozone combining with nitric oxide [NO]) to cause light to be emitted. This light is measured with a photomultiplier tube, similar to the SO_2 fluorescence analyzer.

E.1.9 EPA METHOD 8 (STACK SAMPLING)

This method is applicable for the determination of sulfuric acid mist (including SO_3) and SO_2 emissions from stationary sources. A gas sample is extracted isokinetically from the stack. The sulfuric acid mist and SO_2 are separated, and both fractions are measured separately by the barium-thorium titration method.

E.1.10 EPA METHOD 10 (CEM)

When CEM systems are in place, Method 10 may be used to measure CO concentration. A gas sample is continuously extracted from the stack and a portion of the sample is conveyed to an instrumental NDIR analyzer for determination of CO concentration. The principle of operation is similar to the NDIR SO_2 analyzer.

E.1.11 EPA METHOD 10B (STACK SAMPLING)

An integrated bag sample is extracted from the sampling point and analyzed for CO. The sample is passed through a conditioning system to remove interferences and collected in a Tedlar[®] bag.

The CO is separated from the sample by a gas chromatograph (GC) and catalytically reduced to methane (CH_4) prior to analysis by flame ionization detection (FID).

E.1.12 EPA METHOD 19

This method is applicable for:

- Determining PM, SO_2 , and NO_x emission rates;
- Determining sulfur removal efficiencies of fuel pretreatment and SO_2 control devices;
- Determining overall reduction of potential SO_2 emissions; and
- Determining SO_2 rates based on fuel sampling and analysis procedures.

Pollutant emission rates and SO_2 control device efficiencies are determined from concentrations of PM, SO_2 , or NO_x , and O_2 or CO_2 , along with F factors (ratios of combustion gas volumes to heat inputs).

E.1.13 EPA METHOD 25 (STACK SAMPLING)

This method is applicable for the determination of total gaseous nonmethane organic (TGNMO) emissions as carbon. A gas sample is extracted from the stack at a constant rate through a heated filter and a chilled condensate trap by means of an evacuated sample tank. After sampling is completed, the TGNMO emissions are determined by independent analysis of the condensate trap and the sample tank fractions and combining the analytical results. The organic content of the condensate trap fraction is determined by oxidizing the nonmethane organics to CO_2 and quantitatively collecting the effluent in an evacuated vessel; then, a portion of the CO_2 is reduced to CH_4 and measured by FID. The organic content of the sample tank fraction is measured by injecting a portion of the sample into a GC equipped with a capillary column capable of separating the nonmethane organic emissions from CO, CO_2 and CH_4 .

E.1.14 EPA METHOD 25A (CEM)

This method applies to the measurement of total gaseous organic concentrations of vapors consisting primarily of alkanes, alkenes, and aromatic hydrocarbons. A gas sample is extracted continuously from the source through a heated sample line and directed to the total hydrocarbon analyzer that uses FID. The sample gas enters the detector and is combusted in a hydrogen flame. The ions and electrons formed in the flame enter an electrode gap, decrease the gas resistance, and allow a current to flow in an external circuit. The resulting current is proportional to the

instantaneous concentration of total hydrocarbons. The concentration is expressed in terms of methane or propane.

E.1.15 EPA METHOD 29 (STACK SAMPLING)

This method is applicable for the determination of chromium, cadmium, arsenic, nickel, manganese, beryllium, copper, lead, selenium, silver, antimony, and mercury emissions from stationary sources. The stack gas sample is withdrawn isokinetically. Particulate emissions are collected in the probe and on a heated filter while gaseous emissions are collected in solutions of acidic hydrogen peroxide and acidic potassium permanganate. The recovered samples are digested and the appropriate fractions are analyzed by atomic absorption spectrophotometry.

E.1.16 EPA METHOD 0030 (STACK SAMPLING)

Method 0030 is a manual method for collecting VOCs which are defined for purposes of this method as those organics with boiling points less than 100°C. The gas sample is collected from the sampling point and cooled to 20°C by passing through a water-cooled condenser and the volatile organics are collected on a pair of sorbent resin traps. The resin traps are then analyzed in the laboratory using a gas chromatograph equipped with an electron capture detector (ECD), flame ionization detector (FID), or mass spectrometer to determine speciated organics.

E.1.17 EPA METHODS 201 AND 202 (STACK SAMPLING)

In this method, a gas sample is isokinetically extracted from the source. An in-stack cyclone is used to separate PM with a diameter greater than 10 micrometers, and an in-stack glass fiber filter is used to collect the PM₁₀. The particulate mass is determined gravimetrically after removal of uncombined water. Method 202 is used to determine the condensable PM. The condensable PM is determined gravimetrically by analysis of the impinger fractions.

E.2 OTHER METHODS

E.2.1 CONTINUOUS FLOW RATE MONITORS

A new monitoring requirement under Acid Rain regulations (Title IV of the CAAA) is the measurement of exhaust gas velocities. There are three velocity monitoring techniques applicable to utility stacks or exhaust ducts. These are: (1) ultrasonic flow monitors, (2) thermal flow monitors, and (3) differential pressure monitors.

Ultrasonic monitors operate by passing a pulse of ultrasonic sound diagonally through the moving stack gas. The frequency of the ultrasonic pulse is changed in proportion to the velocity of the stack gas. This frequency shift is measured and gas velocity is then calculated.

Thermal flow monitors operate by inserting a heated element into the exhaust stream. As gas moves over the probe, the heated element is cooled thus requiring additional power to be supplied to the heater in order to maintain a constant temperature. This additional power is proportional to the gas velocity being measured.

Differential pressure monitors measure the difference between the velocity head and static pressure. This difference is proportional to the velocity of the gas stream. The gas flow rate is then calculated using this pressure difference.

E.2.2 FUEL ANALYSIS (ASTM D1552-83/D4507-81)

SO₂ emissions from combustion sources can also be estimated by fuel analysis. The fuel is analyzed for sulfur content and emissions are calculated based on the assumption that all of the sulfur is converted to SO₂. Depending on the characteristics of the fuel ash, a portion of the SO₂ may be absorbed onto the ash (generally less than 5 percent). The remainder is emitted.

E.2.3 FUEL ANALYSIS (SW 846 METHODS 3040/7090)

Metal emissions from combustion sources can also be estimated by fuel analysis. The fuel is analyzed for the metals of interest and emissions are calculated assuming all of the metals are emitted. Because most of the metals are associated with either boiler ash or PM (which may be collected by an air pollution control system), this approach will provide a conservative emission estimate.

E.2.4 FLUX CHAMBER MEASUREMENT

Flux chamber measurement is a direct measurement technique used to estimate emissions from area sources of fugitive emissions such as contaminated soil, landfills, and lagoons. The approach employs an emission isolation flux chamber to obtain an estimate of the amount of pollutant, or pollutants, being emitted from a given surface area per unit time. A variety of flux chamber equipment designs and operating procedures have been employed. EPA has issued guidance identifying flux chamber measurement as a recommended method of estimating baseline air emissions from Superfund sites (EPA, 1990).

E.2.5 OPTICAL REMOTE MEASUREMENT

Another method used to estimate emissions from open areas or otherwise inaccessible sources (e.g., plumes from smoke stacks, hazardous waste landfills) is the use of optical remote sensing (ORS). ORS is an open-path method of determining pollutant concentration using optical absorption spectroscopy. Pollutant concentration data combined with on-site meteorological data may then be used to estimate emissions. ORS techniques include Fourier transform spectroscopy,

differential optical absorption spectroscopy, laser long-path absorption, differential absorption lidar, and gas cell correlation spectroscopy.

E.3 REFERENCE

EPA. 1986. *Test Methods for Evaluating Solid Waste*, SW-846, Third Edition, U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response. Washington, D.C.

EPA. 1990. *Procedures for Conducting Air Pathway Analyses for Superfund Activities, Interim Final Documents: Volume 2 -- Estimation of Baseline Air Emissions at Superfund Sites*. EPA-450/1-89-002a (NTIS PB90-270588), August.

ASTM. *Annual Book of ASTM Standards*, Volumes 06.01 and 15.05. September 1992.

APPENDIX F

EMISSION ESTIMATION TOOLS

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This appendix describes emission factor databases, models, and other data tools that may be useful or required for inventory preparation. Specific emissions measurement are generally the best and most accurate method to quantify emissions; however, source data are not always available. As an alternative, emission factors and models can be used as tools to estimate air pollutant emissions for inventory purposes.

An emission factor relates a quantity of air pollutant to a process parameter, so that if the process parameter is known, an estimate of emissions can be made. For example, an emission factor in the form of pounds of volatile organic compound (VOC) per ton of product can be used to estimate VOC emissions from a source, if the weight of product is known or can be determined.

A more complex model is used to estimate emissions when emissions are not directly related to any one parameter. Models may use computers so that a large number of equations and interactions can be easily calculated. The data requirements for such models vary but in most cases, at least one physical parameter is needed from the source for which the model will be used to estimate emissions. The reader should refer to Appendix C for contact information or to request the most current version available for each of the tools discussed below.

F.1 LOCATING AND ESTIMATING EMISSIONS OF . . . DOCUMENTS

In addition to AP-42, EPA has published about 40 reports, each with the title, *Locating and Estimating Air (Toxic) Emissions From (or of) Source Category (or Substance)*. These reports (also known as L&Es) identify the source categories for which emissions of a substance have been characterized. The reports include general process descriptions of the emitting processes identifying potential release points and emission factors. Table 1.F-1 lists the available L&E documents, which are available by contacting the EPA's Emission Factors and Inventory Group (EFIG), downloading from the EPA Clearinghouse for Inventories and Emission Factors Bulletin Boards System (CHIEF BBS), or ordering through the National Technical Information Service (NTIS).

F.2 EMISSION FACTOR DATABASE SYSTEMS

F.2.1 DATABASES AND SYSTEMS

The most comprehensive compilation of emission factors for hazardous air pollutants (HAPs) is available in the Factor Information Retrieval (FIRE) System, which is available from EPA on one 5.25 inch high density diskette [via request from the Info CHIEF helpline (see Appendix C)] or by downloading from the CHIEF BBS. FIRE contains emission factors for 106 toxic and criteria pollutants from various source categories (EPA, 1995).

TABLE 1.F-1

LOCATING AND ESTIMATING DOCUMENT SERIES

Substance or Source Category	EPA Publication Number
1,3-Butadiene (revised)	EPA-454/R-96-008
Acrylonitrile	EPA-450/4-84-007a
Arsenic	In Production - 1997
Benzene (under revision)	EPA-450/4-84-007q
Cadmium	EPA-454/R-93-040
Carbon Tetrachloride (under revision)	EPA-450/4-84-007b
Chlorobenzenes	EPA-454/R-93-044
Chloroform (under revision)	EPA-450/4-84-007c
Chromium	EPA-450/4-84-007g
Chromium, supplement	EPA-450/2-89-002
Coal and Oil Combustion Sources	EPA-450/2-89-001
Cyanide Compounds	EPA-454/R-93-041
Dioxins/Furans	In Production - 1997
Epichlorohydrin	EPA-450/4-84-007j
Ethylene Oxide	EPA-450/4-84-007l
Ethylene Dichloride	EPA-450/4-84-007d
Formaldehyde (under revision)	EPA-450/2-91-012
Lead	In Production - 1997
Manganese	EPA-450/4-84-007h
Medical Waste Incinerators	EPA-454/R-93-053
Mercury and Mercury Compounds (under revision)	EPA-453/R-93-023
Methyl Chloroform	EPA-454/R-93-045
Methyl Ethyl Ketone	EPA-454/R-93-046
Methylene Chloride	EPA-454/R-93-006
Municipal Waste Combustors	EPA-450/2-89-006
Nickel	EPA-450/4-84-007f
Organic Liquid Storage Tanks	EPA-450/4-88-004
Perchloroethylene and Trichloroethylene (under revision)	EPA-450/2-89-013
Phosgene	EPA-450/4-84-007i
Polychlorinated Biphenyls (PCBs) (under revision)	EPA-450/4-84-007n
Polycyclic Organic Matter (POM) (under revision)	EPA-450/4-84-007p
Sewage Sludge Incinerators	EPA-450/2-90-009
Styrene	EPA-454/4-93-011
Toluene	EPA-454/R-93-047
Vinylidene Chloride	EPA-450/4-84-007k
Xylenes	EPA-454/R-93-048

Factor Information Retrieval System

The EPA's Factor Information Retrieval System (FIRE) is a user friendly, menu driven system. FIRE is a consolidation of emission factors for criteria pollutants and HAPs found in older EPA databases such as Crosswalk/Air Toxic Emission Factor (XATEF), and Aerometric Information Retrieval System (AIRS) Facility Subsystem Emission Factors (AFSEF), as well as emission factors from EPA documents such as *AP-42* and the L&Es. FIRE also contains emission factors for some sources based on single source tests or literature-reported values, where no *AP-42* or L&E data are available. These factors are primarily for HAPs.

Additional and updated emission factors from *AP-42* supplements and new L&Es are entered into FIRE annually. Each emission factor in FIRE also includes information about the pollutant (Chemical Abstract Services [CAS] numbers and chemical synonyms) and about the Source Classification Codes [SCCs] and descriptions). Each emission factor entry includes supporting data such as process parameters, source test methods, control devices, emission factor ranges and/or source conditions, as well as the references where the data were obtained. The emission factor also includes a factor quality rating.

The FIRE database has been designed to be very "user friendly." Data can be searched in many different ways and can be downloaded to print standard reports, or can be printed in a report format that is designed by the user. The FIRE database can be accessed on the EPA's CHIEF electronic bulletin board system.

SPECIATE

The VOC/PM Speciation Database Management System (SPECIATE, Version 1.5) is a clearinghouse for speciation profiles (not emission factors) for both VOCs and PM used primarily for photochemical modeling and source-receptor modeling (EPA, 1993). Each profile lists the elements or compounds identified as being emitted by a source category or process according to the weight percent of each compound as a function of total organic compounds or PM emissions. The SPECIATE PM profiles include three particle size range distributions and total measured PM data for each species. SPECIATE is designed to search for profiles based on a user-provided SCC, pollutant name, or a source category description. Because this system represents a compilation from available literature for use in EPA's photochemical modeling efforts, it will not address toxic compounds with any degree of completeness or accuracy.

The SPECIATE database is updated annually, and is accompanied by a user's manual. The SPECIATE database is available for downloading from the CHIEF BBS or website. All user related questions should be directed to the InfoCHIEF help line.

F.3 CLEARINGHOUSE FOR INVENTORIES AND EMISSION FACTORS BULLETIN BOARD

CHIEF is maintained by the EPA's Emission Factor and Inventory Group in Research Triangle Park, North Carolina. As a clearinghouse, CHIEF is the repository of the most up-to-date information on inventories and emission estimation tools, such as emission factors.

The CHIEF bulletin board contains all of the *AP-42* stationary source volumes and draft revisions, the SPECIATE database, the MOBILE5a model, the AFS database, e-mail from other users of CHIEF. Other information may be available in the future. CHIEF may be accessed on the internet at the following address: tnwww.rtpnc.epa.gov.

F.4 AEROMETRIC INFORMATION RETRIEVAL SYSTEM BULLETIN BOARD

The AIRS bulletin board is an electronic bulletin board maintained by the EPA that holds information useful to AIRS users. The AIRS bulletin board can be accessed through a telephone line modem and provides information on utility information, file transfers, communications, and public communications.

F.4.1 ACCESSING THE SYSTEMS

Most of the EPA materials described in this section are available through the CHIEF BBS or on Air CHIEF CD-ROM. Any user accessing the CHIEF BBS can download *AP-42* chapters, *Locating and Estimating Emissions of...* documents, FIRE, SPECIATE, TANKS, Surface Impoundment Modeling System (SIMS), the AIRS Facility Subsystem Emission Factors (AFSEF) database, and many more tools for estimating emissions. The CHIEF BBS is a subpart of the EPA's Office of Air Quality Planning and Standards (OAQPS) Technology Transfer Network (TTN).

The Air CHIEF CD-ROM for accessing many of EPA's documents and databases is available for purchase from the Government Printing Office (GPO) for about \$20 or from InfoCHIEF (see Appendix C). Users need an IBM™ - compatible personal computer (PC) with a VGA monitor, MS-DOS version 3.0 or later, 8 megabytes (MB) random access memory (RAM), a CD-ROM drive, an interface card, and MS-DOS CD-ROM extensions. Version 4.0 of Air CHIEF CD-ROM includes Volume I of *AP-42, 5th Edition* (criteria pollutant emission factors for point and area sources, not including mobile sources), FIRE, SPECIATE, and 32 documents in the *Locating and Estimating Emissions of...* series. The Air CHIEF CD-ROM is updated annually.

F.5 GEOGRAPHIC MODELING SYSTEMS SUPPORT

Computerized modeling systems can be used in many facets of the emissions inventory to locate emissions sources and track the progress of a control strategy. The most common of these systems are the Geographic Information System and the Global Positioning System.

F.5.1 GEOGRAPHIC INFORMATION SYSTEM

The Geographical Information System uses modern computer technology to store, retrieve, analyze, update, and display spatially arranged data (maps). Because the characterization of emissions is enhanced by knowledge of the location and spatial arrangement of all identified sources, the Geographical Information System can be a useful tool for emissions inventories. Locating each point source, defining the boundaries around each area source, and mapping all road networks can provide valuable information for formulating, evaluating, and implementing emissions reduction strategies. Mapping point and area sources is also important in defining, and subsequently modifying, nonattainment area boundaries. Map features are available in digital formats from transportation departments, tax offices, planning/zoning offices, and emergency response agencies.

Further information about the potential applications of the Geographical Information System technologies in emissions inventory preparation can be obtained from the EPA's OAQPS, and Office of Research and Development (ORD), Research Triangle Park, North Carolina; local colleges or universities with geography, civil engineering, or natural sciences departments; state and local land/resource management or environmental protection agencies; and private organizations that provide mapping services.

F.5.2 GLOBAL POSITIONING SYSTEM

The Global Positioning System performs map feature registration using banks of geosynchronous Earth-orbiting satellites that act as known reference points in triangulation calculations. The coordinates of the unknown Earth surface location can be calculated from the known coordinates of orbiting satellites. This can serve as a valuable quality assurance/quality control (QA/QC) check for locating point source data. Geographical positioning units offer a cost-effective alternative for locating emissions sources, assuming that a registration accuracy of plus or minus three meters will provide adequate mapping resolution within a nonattainment area that covers tens or hundreds of square miles. It is anticipated that as Global Positioning Systems become cheaper and more common, they will be the standard method of determining coordinate locations, if the required accuracy goal can be achieved. Other methods, such as map reading, address matching, and zip code centroids may then decrease in popularity.

The EPA locational data policy (LDP), which became effective in 1995, prescribes that latitude/longitude coordinates be maintained for all EPA facility data (i.e., all media, not just air). The coordinates are to have an accuracy goal of ± 1 second.

F.6 WATER AND WASTEWATER AIR EMISSIONS MODELS

F.6.1 CHEMDAT8

CHEMDAT8 is a Lotus 1-2-3[®] spreadsheet prepared by the EPA's Emission Standards Division that includes analytical models for estimating VOCs from treatment, storage, and disposal facility (TSDF) processes. The original models include disposal impoundments, closed landfills, land treatment facilities, and aeration and nonaeration impoundment processes. Predicted emissions can be viewed on the screen or printed. A graphical presentation of the relationships between emission prediction and vapor pressure and between emission prediction and the partition coefficient is also available. The resulting scatter diagrams can be printed via PrintGraph[®], another Lotus[®] program.

The models in CHEMDAT8 can be applied to other types of TSDF processes besides those contained in the original design. The nonaerated impoundment model in CHEMDAT8 can estimate emissions from storage surface impoundments and open-top wastewater treatment tanks. The CHEMDAT8 aerated impoundment model may be used for predicting emissions from surface treatment impoundments and aerated wastewater treatment tanks. The land treatment model in CHEMDAT8 can estimate emissions from land treatment soil, open landfills, and wastepiles. Emissions from an oil film surface in a land treatment facility or an oil film on surface impoundments can be predicted via the oil film model in CHEMDAT8. When a CHEMDAT8 model is not available to predict emissions, the equations shown in the reports that provide the background to the model can be used to perform hand calculations of emissions.

This eighth version of the CHEMDAT spreadsheet contains several major operational modifications. In CHEMDAT8, the user can select a subset of target compounds for investigation. The user can also specify which TSDF processes are to be considered during a session. These two selections improve the efficiency of CHEMDAT8 relative to some of the earlier versions by minimizing storage requirements as well as actual loading and execution time.

Default input parameters in the CHEMDAT8 diskette demonstrate example calculations. However, the input parameters can be changed to reflect different TSDF characteristics and then recalculate emissions under these modified conditions. The list of 60 compounds currently in CHEMDAT8 can be augmented by an additional 700 chemicals. Procedures for introducing data for additional compounds into CHEMDAT8 are described in the supporting documentation report.

F.6.2 WATER8

WATER8 is a menu-driven computer program that is intended for estimating emissions from wastewater treatment systems only. WATER8 uses some of the same models found in CHEMDAT8, but has data for a total of 800 compounds. The WATER8 program also has graphic enhancements to aid the user in visualizing the system being modeled.

F.7 LANDFILL AIR EMISSIONS ESTIMATION MODEL

The Landfill Air Emissions Estimation Model (LAEEM) is a computer program specifically designed for use by state and local regulatory agencies to monitor the emissions of HAPs from landfills. The system allows the user to enter specific information regarding the characteristics and capacity of an individual landfill and to project the emissions of methane, CO, nonmethane organic compounds, and individual HAPs over time using the Scholl Canyon decay model for landfill gas production estimation. The Scholl Canyon Model is a first-order decay equation that uses site-specific characteristics for estimating the gas generation rate. In the absence of site-specific data, the program provides conservative default values. The user also may tailor decay rate characteristics on an individual basis. An integrated decay rate constant calculator is provided for landfills that may be operating a gas recovery system to allow more accurate assessments of decay attributes. Outputs may be reviewed in either tabular or graphical forms. A help system is also provided with information on the model operation as well as details on assumptions and defaults used by the system.

The model is IBM™-PC compatible, requires at least 512 kb of memory, and can be used with a monochrome or color graphics adaptor. It is recommended that the user's guide be thoroughly read before using the model.

F.8 TANKS

The TANKS program is designed to estimate emissions of organic chemicals from storage tanks. After the user provides specific information concerning the storage tank and its contents, the TANKS program estimates the annual or seasonal emissions and produces a report. The emissions can be separated into standing storage and working losses.

The TANKS program has a chemical database of over 100 organic liquids and meteorology data from over 250 cities in the U.S. The user may add new chemicals and cities to their version of the database. The tank types addressed in the program include vertical and horizontal fixed roof tanks, and internal and external floating roof tanks. The tank contents can consist of single-component liquid or a multicomponent mixture.

The disadvantage of using the TANKS program or *AP-42* equations is that more resources are required to gather the input data and use the equations or program than are needed to use other approximation techniques. If storage tank emissions are expected to be small relative to emissions from other sources in the inventory, the extra effort may not be warranted. A compromise is to develop region-specific default emission factors using the *AP-42* equations or TANKS program that reflect average temperature, tank conditions, and chemical contents for the inventory region.

TANKS version 3.0 is currently available. The program is written in FoxPro™, a dBase-compatible language, and is distributed by the EPA through the CHIEF BBS or through the mail on diskette.

F.9 TRADE ASSOCIATIONS

Trade associations are another information resource regarding emission estimation tools and software for a specific industry. The larger trade associations (e.g., the Aluminum Association or the American Iron and Steel Institute) often serve as liaisons between government and industry. As such, they sometimes support environmental research and negotiations with EPA and other federal agencies. Trade associations may be able to provide emission factor information, test data, control system performance data, and other useful information to industry personnel. Many relevant associations are listed in the *National Trade and Professional Associations of the United States* directory (Russell 1992).

F.10 REFERENCES

EPA. 1993. *VOC/PM Speciation Data System Documentation and User's Guide, Version 1.5*. EPA-450/4-92-027. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. Research Triangle Park, North Carolina.

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